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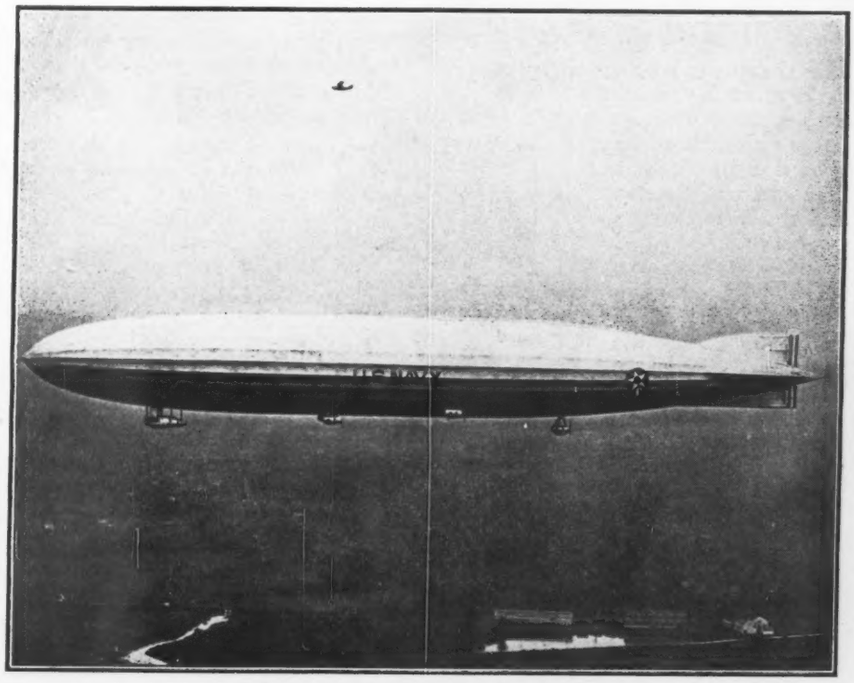
MARCH, 1925



UNITED STATES AIRSHIP SHENANDOAH

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What is the Old Dutch Process?

AMONG industrial processes, there are a few which have become time-honored, notwithstanding cheaper methods which have tried to dislodge them.

The Old Dutch Process for making white lead stands in this group. Invented by the early Venetians, it was adopted by the Dutch and popularized when their trade was world-wide. After hundreds of years it is still required for the making of the finest white lead.

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Corroding pot and uncorroded "Buckles"

The time factor makes the Old Dutch Process costly to the manufacturer. New and shorter methods are tried—but Nature still holds her own, and demands this tribute for her qualities of beauty and endurance. Other processes produce pigment particles of mechanical regularity in size and shape—but the irregularity of Old Dutch Process particles is the real reason for the greater opacity of Old Dutch Process White Lead.

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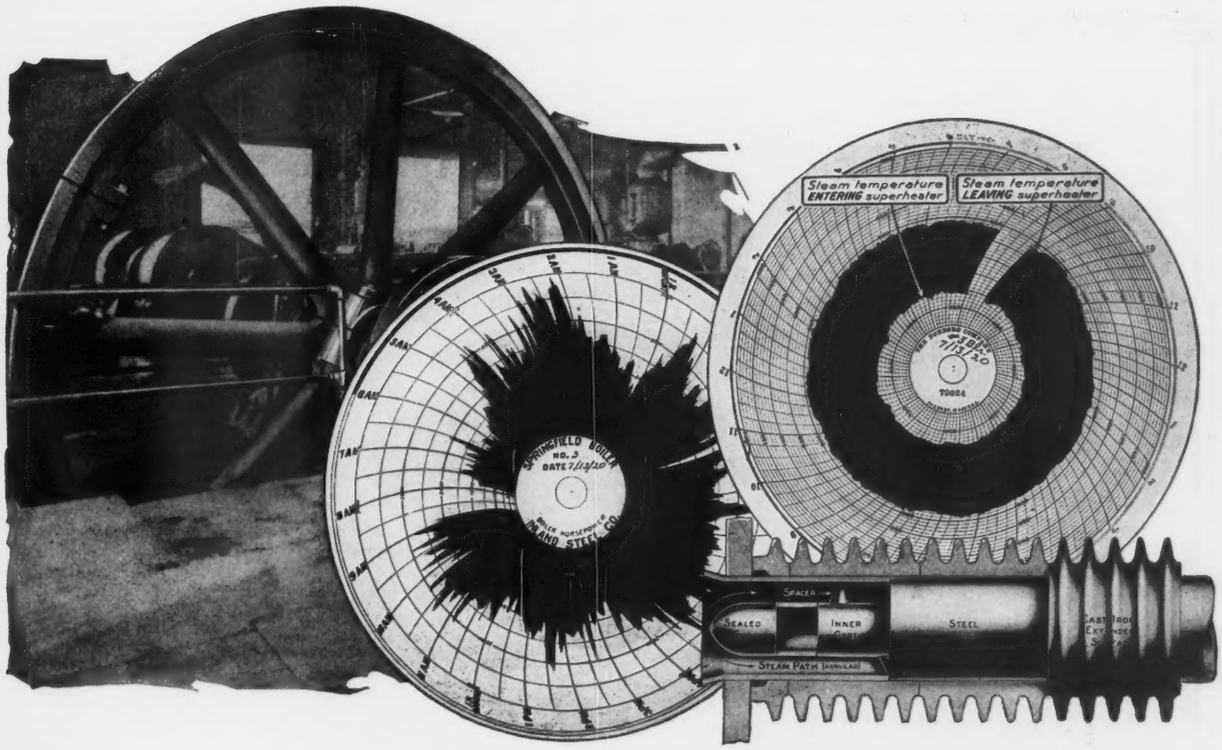

The superheater with the flywheel action

Advantages of Foster Superheater Construction

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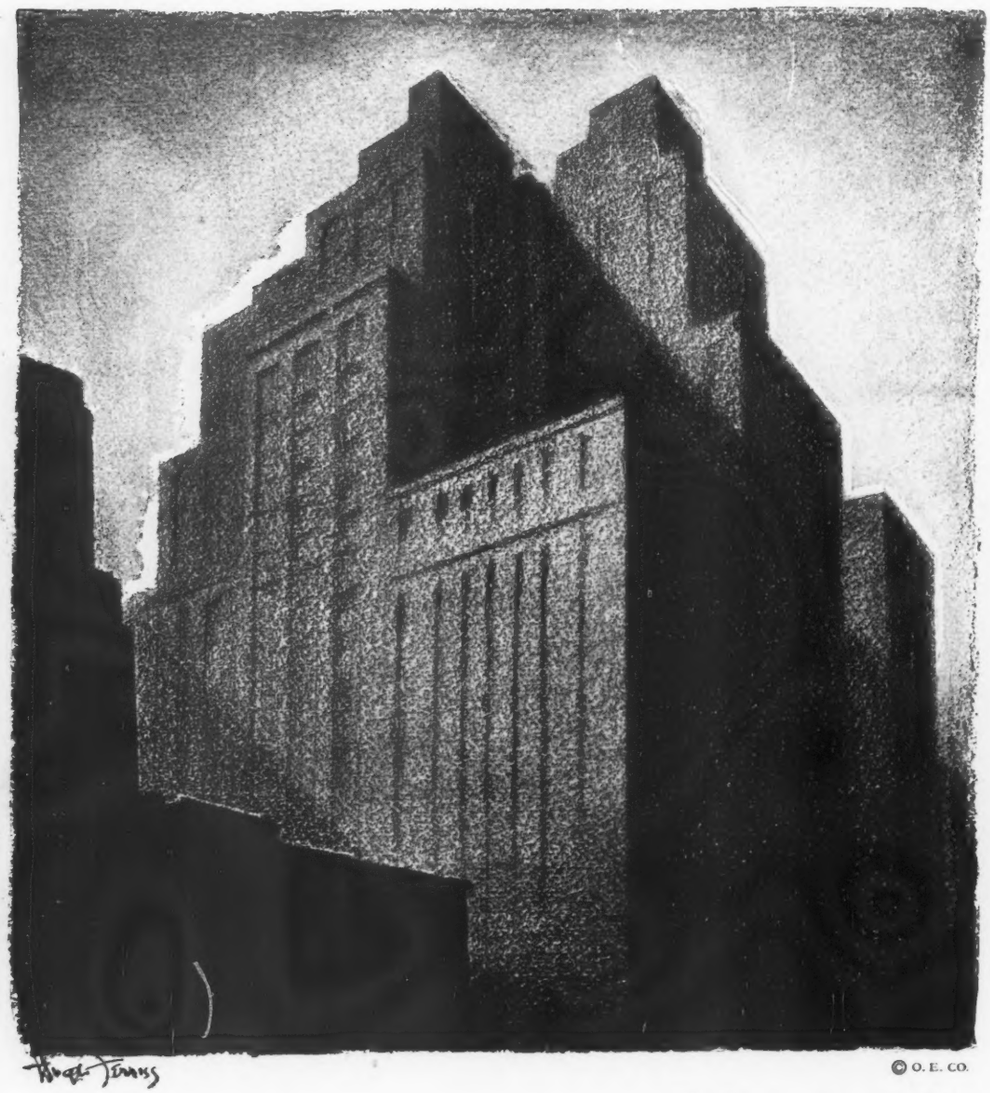

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The Garment Center Buildings
New York City
WALTER M. MASON, Architect
Drawn by Hugh Ferriss

"Towering Masses"

HERE the new architecture expresses itself in great vigorous masses which climb upward into the sky with a pyramidal profile—gigantic, irregular, arresting. An earlier, conventional building on the near corner is overshadowed, engulfed in towering masses of the newer building which are prophetic of an architecture of the future which is vividly stimulating to the imagination.

Certainly modern invention—modern engineering skill and organization, will prove more than equal to the demands of the architecture of the future.

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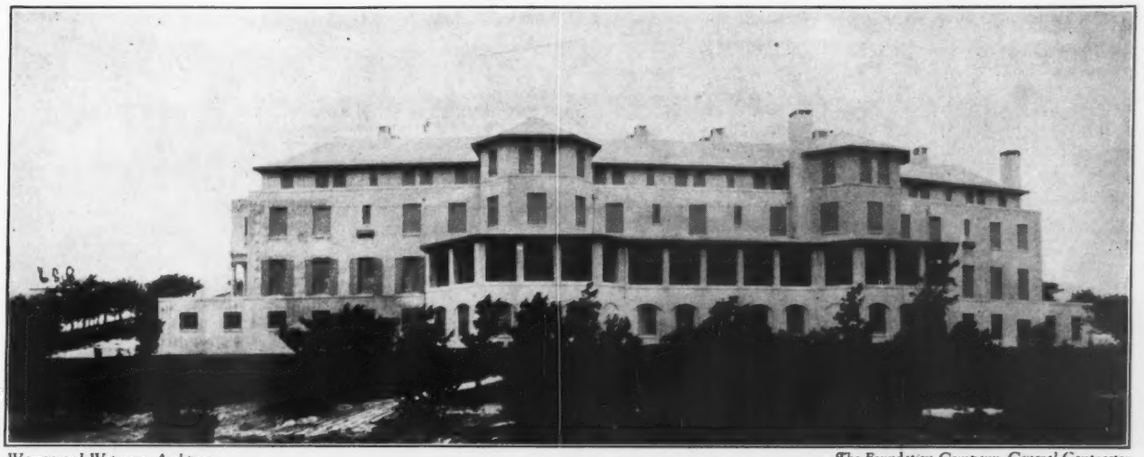
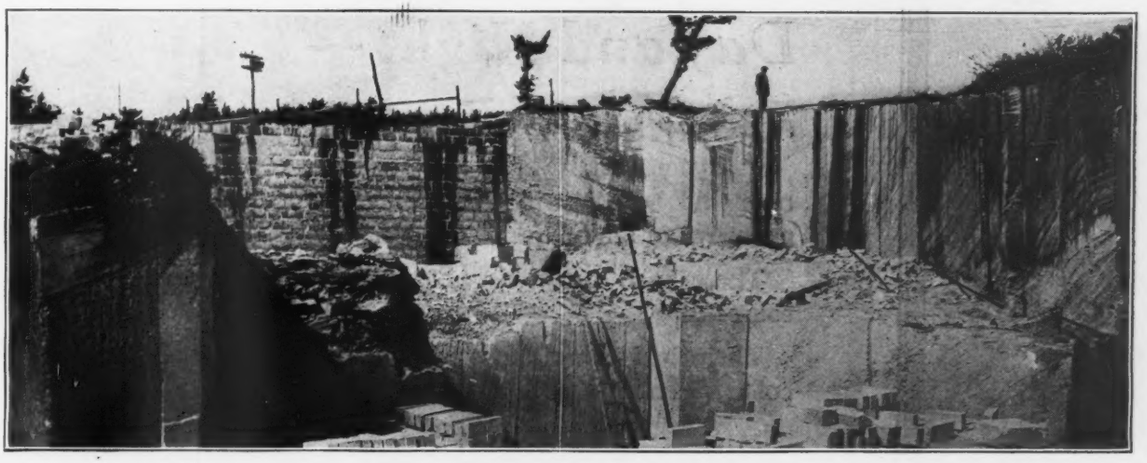


Warren and Wetmore, Architects — *The Foundation Company, General Contractor*

Bermuda Golf Club House, Tuckerstown, Bermuda



Quarry of native stone, used for foundations and walls.

ECONOMY, IN CONJUNCTION WITH GOOD CONSTRUCTION, IS AN IMPORTANT FACTOR IN ALL WORK UNDERTAKEN BY THE FOUNDATION COMPANY. TO FURTHER THE ECONOMICAL CONSTUCTION OF THE CLUB HOUSE AT TUCKERSTOWN, BERMUDA, NATIVE LABOR WAS EMPLOYED, AND A QUARRY, AT THE SITE, WAS OPERATED TO OBTAIN THE CORAL ROCK USED IN BUILDING.

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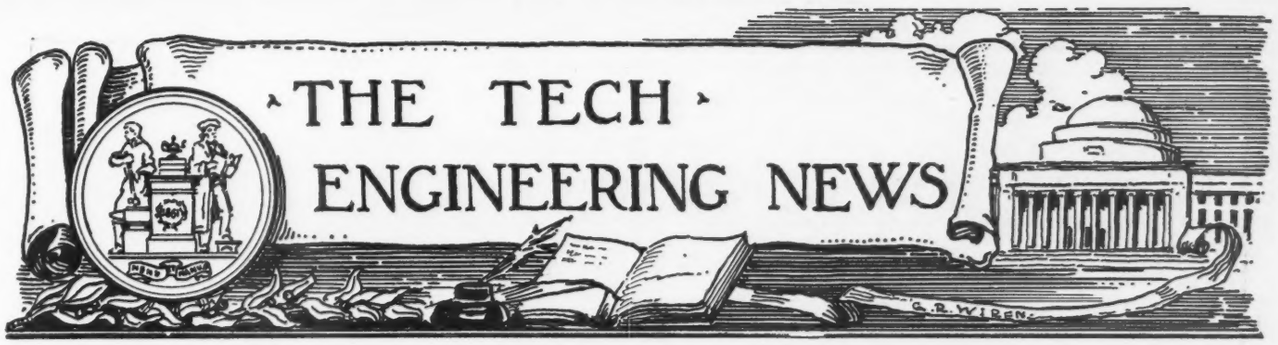

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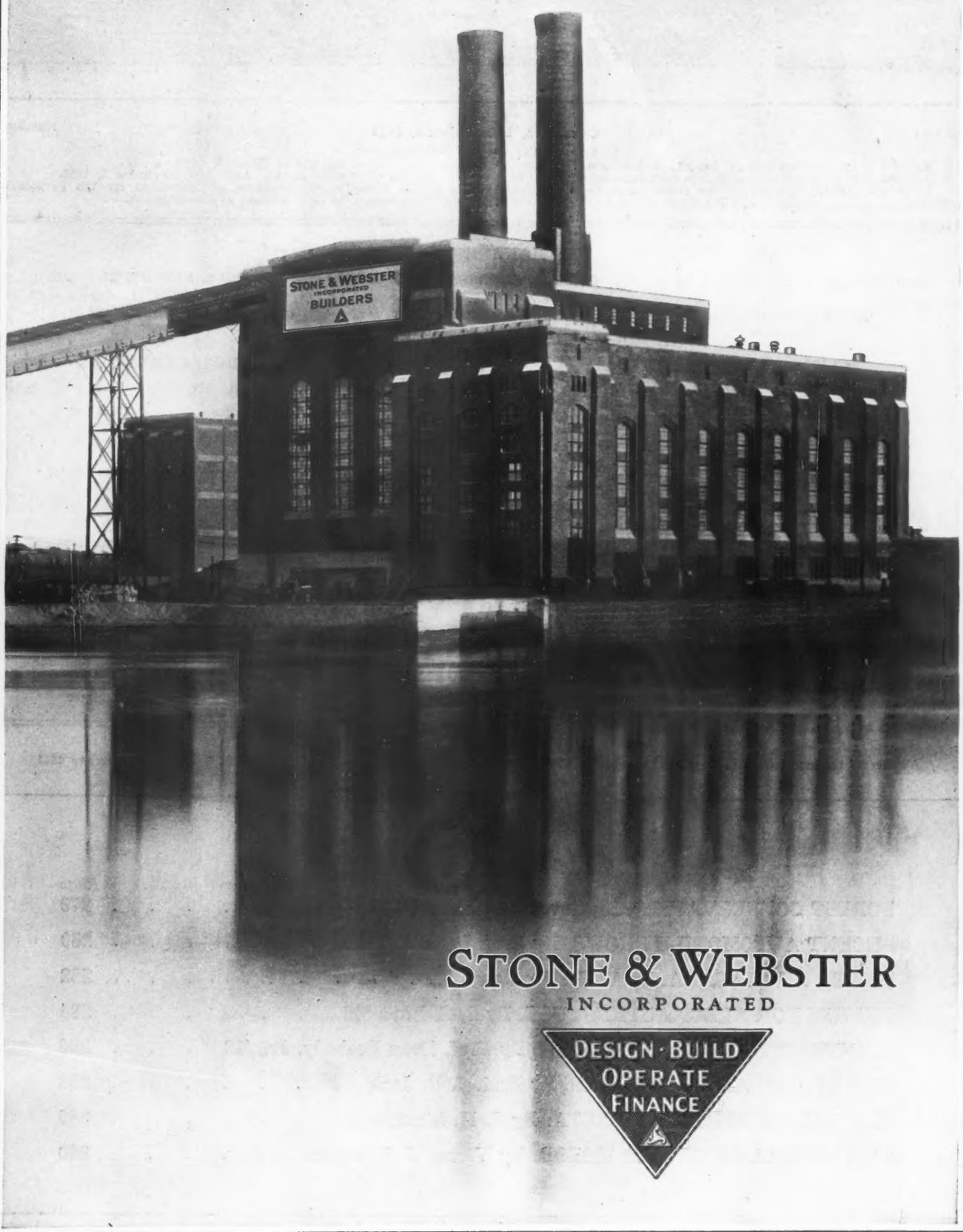

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V | MARCH, 1925 | NUMBER 8

Forest Conservation

A contribution by His Excellency, Gifford Pinchot, Governor of Pennsylvania, formerly head of the U. S. Bureau of Forestry

THE TECH ENGINEERING NEWS,
Massachusetts Institute of Technology,
Cambridge 39, Mass.

DEAR SIRS:

Your letter of January 9 is received. Time permitting, I would be glad to prepare an article for THE TECH ENGINEERING NEWS, but pressing matters of State and the fact that the State Legislature is now in session, prevent my undertaking it at this time. The best I can do at present is to contribute the following short statement on forest conservation to your readers.

The forest plays a leading role in the everyday life of all the civilized people of the world. In some countries the relation between the forest and human welfare is more obvious than in others, but in all of them the standard of living is appreciably influenced by forest conditions.

Many people have overlooked the vital fact that the forest wealth of the world is decreasing rapidly while the population is increasing rapidly. The best available figures show that there are 1,710,000,000 people and 5,500,000,000 acres of productive forest land in the world. This means that there are three acres of forest land for each inhabitant of the world. We need not be alarmed about the acreage of forest land, but there are good reasons for us to be concerned about the deplorable forest conditions that are found upon many of these acres. In the United States alone there are 81,000,000 acres of barren and unproductive forest land. In addition there are 250,000,000 acres that are stocked with inferior trees. Similar conditions exist in other parts of the world. Forest depletion has gone so far that 50 of the important countries of the world are now correctly classed as wood-importing countries.

The wood situation in this country demands serious attention. A recent survey shows that our forests are being drained at the rate of 25 billion cubic feet annually while growth is replacing only six billion cubic feet. Our forest reservoir is thus being depleted four times as fast as wood is growing to feed it. Since there are only 745 billion cubic feet of wood left in the forests of our country, it will not be long until the serious effects of a wood shortage will be upon us. We do not know the wood situation down to the last acre or to the last cord, but we do know it well enough to state that it is serious and that constructive measures must be taken immediately to improve it.

We are the biggest wood users on the face of the earth. The United States annually uses two-fifths of all the wood that is consumed in the world. This fact becomes all the more startling when we realize that practically all the local supplies have been depleted in the eastern part of the country, and yet 50 per cent of the country's total lumber production is consumed east of the Mississippi and north of the Ohio and Potomac rivers.

We are already feeling the effects of a receding timber frontier and of inadequate lumber supplies. The evil consequences thereof will become more intense as the lumber shortage becomes greater and the lumber production becomes more remote from the centers of consumption. Already the annual freight bill on lumber in the United States is $250,000,000, of which $230,000,000 goes to the railroads and $20,000,000 for water transportation. This outlay is on lumber alone. It does not include the freight on mine props, pulp wood, poles, posts, and other forest products. If we consider all the items of wood transportation it is safe to say that the annual freight bill on forest products is not less than $500,000,000. Most of this outlay is unnecessary when we realize that there is plenty of forest land available in the East to produce much of this wood. Wood to fully meet our needs can be grown at home if we put our forests in a wood-producing condition and keep them in order. It is our duty to transform our idle hillsides and barren wastes into productive forests.

Forest conservation is a common enterprise in which all our people must sooner or later participate. The sooner this point of view prevails the better it will be for all of us. The welfare of the world depends to a considerable degree upon the wise handling of forest resources. The forest problem concerns every man, woman and child, for the forest is the fountain of an enduring prosperity. The squandering of our forest heritage and the plundering of our out-of-doors must be stopped. We must no longer look upon the forest as a volunteer product of nature, but as a crop that must be carefully handled and cut with adequate provision of renewal. A forest without small trees has no more chance to endure than a nation without children. We have enjoyed the privilege of being a nation of wood users. To continue to enjoy the advantage and comforts of this privilege we must become a nation of wood-growers.

Sincerely yours,
GIFFORD PINCHOT.

Recent Automobile Shows

The advance in automotive design during 1924-1925

By DEAN A. FALES, '15
Assistant Professor of Automotive Engineering, Massachusetts Institute of Technology

THE outstanding feature of the current automobile shows is the development of the closed body. Practically all manufacturers are exhibiting attractive closed models and in most cases the price of the closed model is approximately the same as that of the open car. With the increase in popularity and production of the Sedan and Coach type of vehicle, it will not be long before the closed cars will sell at a lower price than the open cars. In many of the closed cars a one-piece windshield is used which gives an attractive appearance. Such cars are bound to cause discomfort in some parts of the country in winter weather, as there are times when ice will form on the windshield in spite of wipers. It will then be a question of opening the whole windshield in order to see or, in the case of the vertically-raised windshields, to try to look out of the small opening below the bottom of the windshield. On some of the closed cars the forward pillars are of such size that the driver's vision is restricted. These blind spots are the cause of many accidents and it is hoped that the body builders will develop bodies along such lines that there are no blind spots. A step in this direction has been made by using thin steel pillars and by using sloping windshields with triangular side windows with narrow pillars. The use of fabric for much of the superstructure of closed cars is decreasing body weight and eliminating the drumming noise experienced in some of the early closed bodies. The development of the fabric body will produce lighter, more flexible, quieter, and cheaper bodies.

One of the greatest improvements noted at the shows is the pyroxylin, or lacquer finish. This finish is far better for motor vehicles than the paints formerly used and it can be applied more quickly and cheaply. This finish is colored celluloid that is sprayed on. The finish after spraying has an eggshell surface; this can then be polished to a semi-gloss or satin finish or to a fine finish. There is a tendency to break away from the sombre colors of previous years and more light colors are in evidence.

The car with the vertical eight-cylinder engine has appeared in numbers. At the New York Show ten of these vertical eights were exhibited by as many different manufacturers and there are a half dozen more on the American market. The vertical eight-cylinder engine is clean, easy to service, and is capable of high rotative speed. In operation it is smooth, has little vibration, and gives a car great power of acceleration. Many cars having a vertical eight cylinder engine have a hood no longer than a six, so compact is the engine built. With the high engine speeds greater care is needed in the design and balancing of clutches, transmission shafts and other rotating parts.

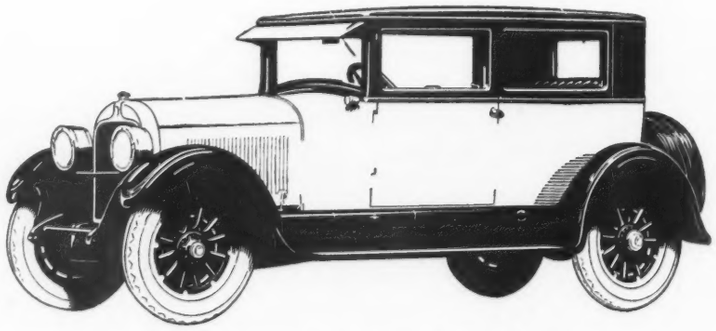
The Vee-type of eight-cylinder engine continues to be popular and gives a compact power plant that can be housed under a comparatively short hood, allowing good body room on the chassis. A number of the ninety degree vee-type eight-cylinder engines are using crank shafts that have their throws in planes at ninety degrees. By using this type of shaft better balance is obtained than is the case with the four-cylinder type of shaft. Several vee-type engines have the angle between the cylinder blocks less than ninety degrees. This permits higher cylinders, makes for a narrower engine and reduces the side shake that is present in the ninety degree vee when a four-cylinder type crank shaft is used.

The six-cylinder engine is gaining in popularity, several new models being shown with engines of this number of cylinders. The six-cylinder engine being excellently balanced is being further developed by the elimination of torsional vibration in the crank and cam shafts.

Four-cylinder engines are shown in the lighter cars in an improved form. For economy in operation and maintenance the four will be popular for some years to come.

About ten years ago a statement was made in connection with French racing cars that a three-inch bore and six-inch stroke was the best cylinder size for a racing engine. It seems now that a three-inch bore is popular as a manufacturing size, although the stroke is not as great as the racing enthusiasts predicted. In some cases it seems that manufacturers use approximately a three-inch bore for a six-cylinder model and for a more powerful model, eight of the same size cylinders are used.

Four-wheel brakes are shown on an increasing number of cars and the fact that the widespread advertising of last year has diminished shows that the public has been educated and accepts this type of equipment. While great improvements have been made in four-wheel brakes during the past year, it is expected that more will be made during the coming year. External four-wheel brakes will probably be replaced by internal brakes. The linings on external brakes are easily wet and collect dirt and grit. When the linings are wet the coefficient of friction is changed and in spite of equalization of the brakes the wheels are not always retarded as they should be with relation to each other. Several types of mechanical four-wheel brakes have been developed, while one type of hydraulic brake dominates its field. Both types are satisfactory provided they are properly installed and cared for. Little has been done in this country with servo or self-energizing four-wheel brakes, but there is promise of great development on these lines during the coming year. The underlying idea in these systems is to make use of some additional device that will apply the brakes by means of small pedal pressures. In the servo mechanisms a mechanical pump can be used



CADILLAC COACH—VEE-TYPE MOTOR

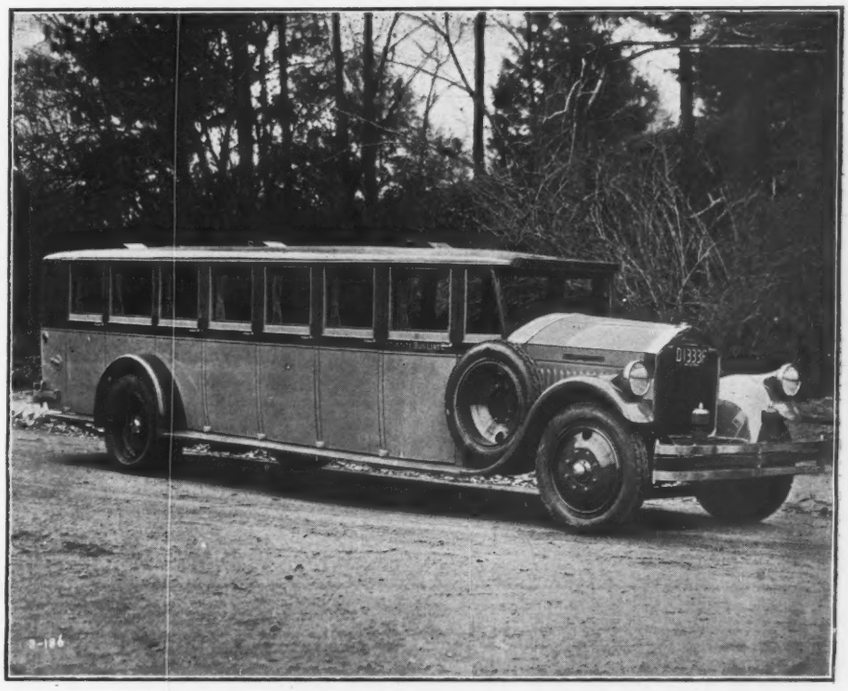
This type of body, selling at open car price, has proven very popular with the motoring public.

to apply the brakes. Another method is to have a small brake whose drag when applied will operate the wheel brakes. In the self-energizing systems one part or shoe when applied forces other parts of shoes against the drum. The self-wrapping brake is an example of this type, but its disadvantage is that it usually works much better in one direction than in the opposite direction.

Balloon tires are shown in great numbers and many changes in spring design, steering, and frame construction have been necessary on their account. To give easy steering with these tires, the ratio of the steering gears has been changed. While this gives the easy steering desired, the amount of steering wheel movement necessary has been greatly increased and in some cases this retards the rapid and precise steering possible with steering gears formerly used for the smaller high-pressure tires. An example of this is correcting a skid or steering out of a snow rut; with some of the balloon tire steering gears, a skid cannot be corrected as quickly as with the older type steering gears and in the case of ruts it is difficult to get out of one rut and recover the intended direction before getting into another rut. Front wheel wobble or shimmy is a problem that has presented itself in some balloon tire installations. Some cars are now built with the front springs anchored at the rear and shackled at the front. In other cases spring design is changed. There is talk of hydraulic steering mechanisms as a cure for this wobble. If wheel wobble is present it is dangerous to drive a vehicle at the speed at which the wobble occurs, as precise steering is impossible. In a great many balloon tire installations some form of snubber or shock absorber is considered necessary. The next year will undoubtedly bring great improvements in the balloon tired vehicle.

Oil filters and rectifiers are being fitted to engines in increasing numbers. The filters remove from the oil the minute particles of metal and dust, thus keeping abrasive matter out of the oil. The rectifiers use exhaust heat to vaporize the fuel and water that may be present in the oil. The vaporized fuel or water is fed into the intake manifold where it is either burned in the engine or passed out with the exhaust gas.

Air cleaners are also being used in greater numbers. By using a good air cleaner, dust is not allowed to enter the engine and with this abrasive matter eliminated from the oil, engine wear is reduced and engine life prolonged. Unfortunately, the better the present air cleaner is the greater is its drag on the air entering the carburetor, which means a restriction of gas going into the cylinders. In some cases the compression ratio of the engines has been increased to counteract this. A possible development is the use of a pump or super-charger in connection with an air cleaner.



PIERCE ARROW INTERURBAN MOTOR COACH

This type of vehicle is revolutionizing urban and interurban travel. The riding comfort is, if anything, better than in most privately operated automobiles.

There is a growing demand for a moderate-sized vehicle that can be easily parked and that can accelerate rapidly for traffic driving and hill climbing. The manufacturers are creating and meeting this demand by producing comparatively light vehicles that are easily handled in traffic and that have the acceleration and speed of the racing cars of only a few years ago. These cars are demonstrating that a car need not be heavy to be easy riding.

No serious attempt is being made to produce vehicles with great fuel economy. If the buying public prefers to drive continuously in high gear, that high gear must be capable of traffic acceleration and hill climbing and when the vehicle is traveling at moderate speed on level roads a great deal of fuel must necessarily be wasted. When some form of constant torque or automatically variable transmission is successfully produced we may look for better mileage.

One of the most notable developments of the year has been the motor coach and bus. This type of vehicle is revolutionizing urban and interurban travel. The bodies are luxurious, the riding comfort is, if anything, better than in most privately-operated automobiles, and the acceleration and speed compares favorably with the privately owned and smaller cars. To make these vehicles so successful, great strides have been made in body design, engine design and chassis construction. For the high speed interurban coaches engines with six cylinders capable of maintaining an output of over a hundred horse power have been developed, while for city use the four-cylinder engine is popular because of its low maintenance and operating costs. An interesting development is the progress the Knight type of sliding sleeve valve engine has made. These engines are now being used in increasing numbers on account of their low cost of upkeep.

Taxicabs have been developed fully as much as the private type of passenger vehicle. The bodies, spring suspensions, and brakes are in some cases superior to corresponding units on cars sold for private use. One example is the rubber and fabric spring shackles that many taxicabs use. By their use the operating companies save money. It seems but a question of time before such equipment will appear on private vehicles.

An interesting comparison to make is that between the vehicles sold for private use and those built to be operated by organizations as cabs, the vehicles must give service, but

(*Continued on page 304*)

Power at Niagara

Installation of three 70,000 H.P. units which will do the work of 9,000,000 men

By W. K. BRADBURY, '09
Niagara Falls Power Co., Niagara Falls

DURING the World War all power interests on the American side of Niagara Falls were consolidated upon the suggestion of representatives of the United States government. The single system resulting is known as The Niagara Falls Power Company. In May, 1918, the Secretary of War authorized the "rush" development of the remaining water from the American side of the Niagara River available under the treaty with Canada, in order that electro-chemicals vital to the successful conduct of the war might be produced in sufficient quantity. Three vertical hydro-electric units, each of 37,500 h.p. capacity, were constructed in record time with an increase in efficiency of converting the natural resource into electrical energy, and without sacrifice of permanency of project.

After the war the Congress of the United States, taking cognizance of the need of developing the water power resources of the country in a large way, created the Federal Power Commission with authority to license power projects and to regulate their operations. The commission's first license was granted to The Niagara Falls Power Company on March 2, 1921. This license confers to the company for fifty years its right to use 19,500 cubic feet a second of the 20,000 c.f.s. of water permitted by international treaty to be diverted from the American side of the river above the falls for power purposes. With the license came formal federal approval of plans to develop all of the diverted water under a minimum head of 214 feet and to place in reserve the Niagara plant on the upper river. Completion of these plans will give the plants on the American side a nominal capacity of 450,000 h.p., or 100,000 h.p. more than formerly when the Niagara plant used a large part of the available water at a lesser head. The project for a waterway, power house, new units, and transmission facilities to carry out the plan involved the expenditure of over $12,000,000.

The Hydraulic Canal, which carries water from the river above the upper rapids to the edge of the cliff beyond the falls, has a nominal capacity of 10,000 c.f.s.—enough to supply thirteen 10,000 -h.p. horizontal, single runner, double-discharge turbines in Station 3-A and three 37,500 h.p. vertical, single-runner turbines in Station 3-B. In order to convey additional water necessary for three 70,000 h.p. units, a new waterway had to be built. Conditions in the city of Niagara Falls, N. Y., due to its remarkable growth since Niagara power made possible the electrochemical and electrothermal industries, made the right of way for an open cut quite out of the question. It was decided to build this waterway in the form of a tunnel, and in April, 1921, ground was broken for its excavation.

With the exception of a small overburden of earth, the entire excavation (278,000 cu. yd.) for the intake basin, tunnel, and forebay was in solid limestone. Around the rim of the intake basin, which adjoins the entrance to the canal a mile above the falls, a steel sheet piling cofferdam was erected. After the water was pumped out of the basin, the rock was excavated in such a manner that the cross-section area of the basin remains nearly constant while the sides converge and the bottom slopes down toward the tunnel entrance. Upstream the basin is 135 feet wide and 30 feet deep. At a point 175 feet downstream, however, at the tunnel inlet it is 60 feet wide and 70 feet deep. The tunnel inlet, 100 feet long, tapers from 60 feet high and 60 feet wide to the true size of the tunnel itself. A plug of rock 25 feet thick was left in the inlet until completion of the tunnel and forebay as a safety measure.

Tunnel excavation was carried on from two shafts and from the outlet at the forebay. One shaft was 950 feet from the inlet at the bottom of a five and one-half per cent grade descending from the inlet; the other shaft was 2,000 feet further downstream. Under each shaft is a drain for unwatering the tunnel, these drains leading to another tunnel on a lower level which serves as a tailrace for the Niagara plant. From a point 300 feet beyond the second shaft the tube rises on a six per cent grade for the last 1,000 feet. The maximum depth of the tunnel floor below the surface is 134 feet, and its total length from inlet to forebay is 4,300 feet.

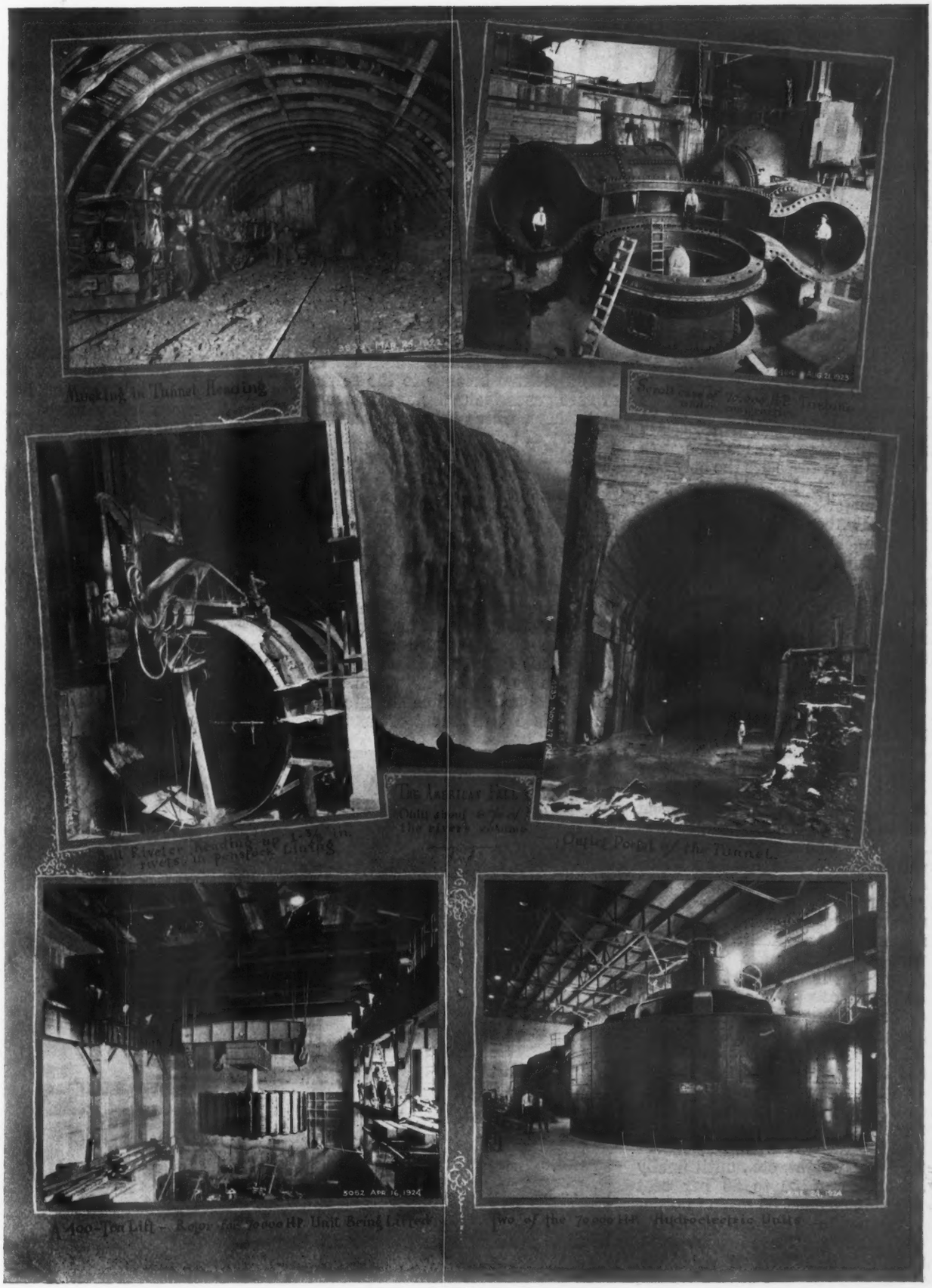
From the bottom of each shaft, headings were driven in each direction by the use of jackhammer drills and dynamite. Ventilation for the men was supplied by electrically driven volume blowers. The bore was 36 feet wide and 18 feet high. Steel arches bent to the proper radius were set about four feet apart to support the roof as fast as the work progressed. Narrow gauge tracks were laid for electric trains to haul away the rock which was loaded into the cars by air-operated shovels on crawler treads. All rock excavated was hauled to the shafts, dumped into elevator buckets, and lifted to hoppers above the surface. Loading by gravity from these hoppers, 21 five-ton motor trucks took the material to dumping grounds two miles away. These Pierce trucks traveling night and day for two years on this tunnel job covered one and a half million miles. The excavated rock would have filled a train of gondola cars over 200 miles long.

After the heading was drilled through the entire 4,300-ft. length (excepting the rock plug at the inlet), the lower part of the tube was excavated. Jackhammer drills bored three separate benches simultaneously. Air-operated shovels and electric trains removed the debris after the blasting. With a minimum of manual labor the work progressed rapidly at the rate of six to eight linear feet every 24 hours. The whole bore was 36 feet high and 36 feet wide, horseshoe shape. In order to provide a smooth surface on the interior so that there would be a minimum of friction for the passage of water, a concrete lining was poured. The tube when lined measured 32 ft. x 32 ft.

The tunnel was designed to carry 10,000 c.f.s. with a loss of about two feet head. In the last 150 feet of its length its cross-section area gradually increases until at the outlet the portal is 50 feet high and 50 feet wide. Then the forebay itself, designed for a stilling pool, continues the expansion of area, its downstream end being 150 feet wide and 60 feet deep. The purpose of the outlet, or diffuser, and the peculiar shape of the forebay is to reduce the speed of the water, clear it of eddies, and allow it to become quite free from all disturbances before entering the penstocks.

Across the downstream end of the forebay stands the gate-house, in the foundation of which are the bell-mouth openings to the three largest penstocks yet built. They are 21 feet in diameter. The gate-house above is built high enough to permit the removal of the gate mechanisms by overhead cranes. It contains apparatus for operating the gates and transformers for stepping up the voltage of the current produced in the power

(*Continued on page 298*)


Working in Tunnel Heading
Scroll case of 70,000 HP Turbine
Rivet Heater heating up 1-3/4 in. rivets for pendstock Lining
The Tailrace Tube
Outlet Portal of the Tunnel
3062 APR 16, 1924
A 400-Ton Lift - Rotor for 70,000 HP Unit Being Lifted
Two of the 70,000 HP Hydroelectric Units

Helium for Aeronautical Use

A discussion of its development and advantages for lighter-than-air ships

By S. C. LIND, '02
Chief Chemist, U. S. Bureau of Mines, Washington, D. C.

THE headline writer of a western daily recently compressed the description of the two properties of helium which make it suitable for aeronautical use into the following irreducible minimum: "Helium will go up but will not blow up." When the truth of this statement is fully appreciated there remains but little to be said except as to some of the details of its utility, such as the following: (1) Can it be found and secured in sufficient quantity; (2) can it be obtained pure at an allowable cost; (3) is its lifting power sufficient; (4) how long will its supply last?

Assuming the general utility of lighter-than-air craft, the value of helium as a lifting gas then becomes merely a matter of comparison with hydrogen, since these are the only two gases sufficiently light to be considered for major aeronautical use.

Physically, both helium and hydrogen are colorless, odorless and much lighter than air. One thousand cubic feet of air at atmospheric pressure and 200° C. weigh 76 pounds. The same volume of hydrogen weighs five pounds and of helium ten pounds (in round numbers). The lifting power of a light gas in a heavier one is the difference in weight of equal volumes of the two gases. Therefore, the lifting power in air of 1000 cubic feet of *hydrogen is 71 pounds* and of *helium 66 pounds*, or 92 per cent of that of hydrogen.

A great deal of attention has been given to this deficiency of 8 per cent in the lifting power of helium. On first thought it would appear to be a simple matter, (1) either to substitute helium for hydrogen in the same gas bags and operate with the remaining 92 per cent of lifting power, or (2) to make the bags 8 per cent larger. The first has been done in the case of the Shenandoah and the Los Angeles, but it involves limiting the cruising radius, owing to the reduced quantity of fuel that could be carried. The second alternative is not merely a matter of increasing the volume of the bag by 8 per cent, for this again calls for additional structure with consequent increase of weight, etc., until finally an increase of 20 to 30 per cent in the volume must be made in order to regain the 8 per cent lifting power. However, these appear to be rather minor structural problems. The fact that the Shenandoah, filled with helium, though designed for hydrogen, did successfully negotiate a transcontinental tour and cross the Sierras at more than 7,000 feet altitude, proves that helium can be used. Had helium happened to be the lightest gas, or had hydrogen been no lighter, all air craft would have been originally designed for that lifting power and no claims of its deficiency would ever have been raised.

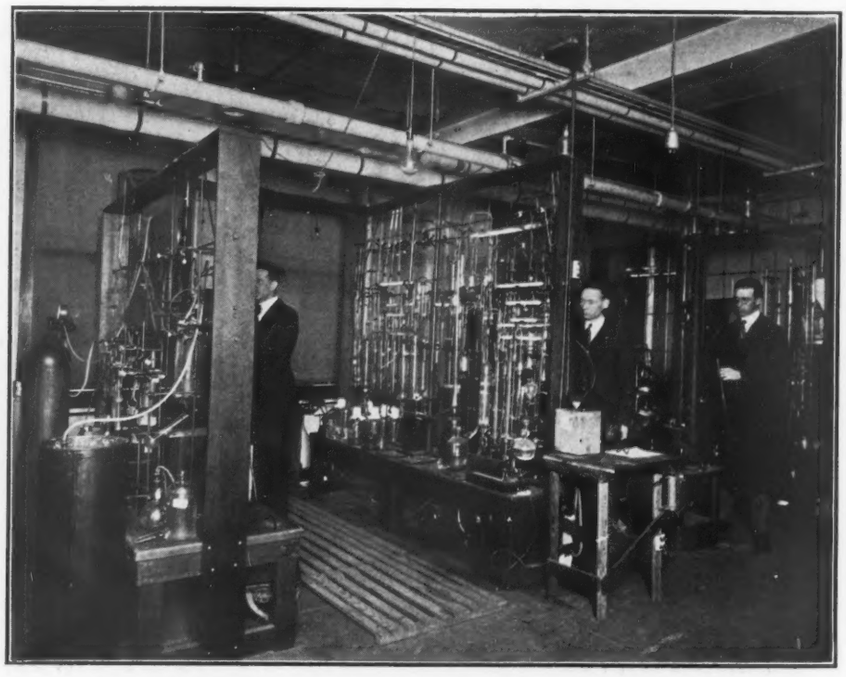
In the chemical properties of the two gases the greatest difference is found. Helium belongs to the series of rare gases including argon, neon, and others, which have the common property of being chemically inert or incapable of entering into or existing in chemical combination. Herein lies the great advantage of helium,—its non-inflammability. Since helium cannot be obtained from any chemical compound, we are dependent on finding it in the free state in nature. The case with hydrogen is quite the opposite. It is not only inflammable or combustible, but forms violently explosive mixtures with air in all proportions from 10 to 66 per cent of hydrogen by volume. Although it is not available in the free state in nature, it is a constituent of many of our commonest chemical compounds, such as water, acids, fats, oils and all hydrocarbons and carbohydrates, and can be prepared chemically by a large variety of processes and is hence universally available. The one supreme disadvantage of hydrogen which outweighs all of the advantages it may have, its combustibility, has either caused or contributed to the greatest airship disasters of the past. Furthermore, owing to this same property, hydrogen cannot be readily purified after it has become contaminated with air in use, and must be discarded. The annual replacement factor in the bags would be normally about fifteen-fold, which makes its use actually more expensive than helium at its present cost, —assuming, of course, that water condensers will be used on the exhaust gases, so as to maintain weight and avoid loss of helium by valving.

The principal events leading up to the present status of the use of helium have been the following:

Discovery in the sun by its spectral lines (Lockyer and Franklind, eclipse of 1868).

Discovery on the earth in radioactive minerals (Ramsey, 1895). Quantities from this source were very limited—a few cubic feet.

Discovery in quantity (1 to 2 per



CRYOGENIC LABORATORY AT WASHINGTON, D. C.
This laboratory was established at the Bureau of Mines in 1921 to study the properties of the gaseous liquid mixtures encountered in the separation of helium from natural gas by the refrigerative method.

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cent by volume) in the natural gases of Kansas (Cady and McFarland, 1905).

Conception of its possibilities as a military aeronautic gas (by the Allies in 1917, during the World War).

Immediately following the appreciation of the possible value of helium in lighter-than-air craft, a survey of our helium resources was undertaken by the Bureau of Mines and the Geological Survey. A suitable source was discovered in the natural gas from the Petrolia field in Northern Texas, which is used as city gas supply of Dallas and Fort Worth.

With the co-operation of the Army, the Navy, the Bureau of Mines, and commercial companies, an experimental plant was established at Fort Worth. Three methods of recovery were attempted, all of which were dependent on separation of helium as a gas from the other constituents, hydrocarbons (chiefly methane) and nitrogen, after their liquefaction by low temperature methods. Of the three methods, only that of the Linde Air Products Company was successful. The process which this company had employed for the separation of oxygen from air was so modified as to effect the separation of helium from natural gas. A full scale plant of six units, capable of processing 5,000,000 cubic feet of raw gas daily, was erected at Fort Worth. This plant, now known as U. S. Helium Production Plant No. 1, is operated by the Linde Company under the supervision of the Navy, at the joint expense of the Army and Navy. During the past year some six to nine million cubic feet of pure helium (95 to 98 per cent) have been produced for the use of the Navy at Lakehurst, N. J., and of the Army at Scott Field, Belleville, Illinois.

A year ago the cost of production was about $100 per thousand cubic feet of helium. During the past year great progress has been made in improving the process, with consequent reduction in cost. The present cost of production is about $35 to $40 per thousand, with an anticipated reduction to $15 to $20 during the coming year. This will be the manufacturing cost f.o.b. cars at Fort Worth, without allowance for interest on the investment.

In 1919 a Helium Board was formed, comprising representatives of the Army, Navy and Interior Departments. This Board found that new data would be required regarding the properties of the gaseous and liquid mixtures encountered in the separation of helium from natural gas by the refrigerative method, before efficient methods could be devised and plants intelligently designed for the extraction of helium. The Cryogenic Laboratory was established in the Bureau of Mines, at Washington, in 1921, to carry on the researches necessary to secure these data. It was dedicated by Madame Curie in 1921 and put in charge of Dr. R. B. Moore, who had been a leader in the helium work from its inception. The fundamental principles underlying all the improvements in process which have just been referred to resulted from the data obtained in this laboratory, affording a good demonstration of the value of systematic research. It is still conducted with the co-operation of the Army and Navy and at their expense.

HELIUM REPURIFICATION PLANT AT LAKEHURST, NEW JERSEY

The plant repurifies the helium from the gas bags which have become contaminated with air by diffusion and has a capacity of about 480,000 cubic feet of gas per day.

In 1921, Dr. H. F. Bain, Director of the Bureau of Mines, appointed a Board of Consulting Engineers to render a report on one of the three original processes which had not proved successful. The Board, consisting of M. H. Roberts, chairman, R. C. Tolman, W. L. DeBaufre, and Edgar Buckingham, became directly interested in helium production and devised a new process for government use, which has proved successful on a semi-commercial scale. The first unit is now being installed at Fort Worth on a full commercial scale. This process should also be capable of producing very cheap helium—$15 or less per thousand cubic feet.

It is now thoroughly appreciated in this country that lighter-than-air craft cannot be safely operated without helium. The Army and Navy have abandoned the use of hydrogen entirely. Now that the actual success of helium flying has been repeatedly demonstrated by the Navy and Army of the United States, there remain but two primary questions with reference to helium—those of supply and cost. It is admitted by those commercially interested in dirigibles that helium at a cost of $25 a thousand would be acceptable. We have just seen that it can be obtained for this now and that the price is likely to be still further lowered, so that it will actually be cheaper than hydrogen at any cost, even leaving out of account the danger attendant to the use of hydrogen, which involves higher insurance rates and lack of confidence on the part of the investor and of the public as prospective passengers. It is then quite clear that with the use of helium a demonstrated fact, and with its cost reduced to a satisfactory basis, its future will depend alone on whether it can be secured in adequate quantities. The present situation is that the United States possesses the only commercial quantities of helium known. This monopoly has stimulated the military interest in helium, but it is not safe to rely on our retaining this monopoly indefinitely in the future. Other countries may discover helium, or ours

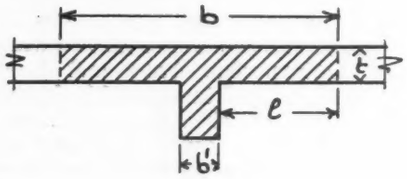
(Continued on page 314)

Reinforced Concrete Design

The principal changes embodied in the 1924 Report of the Joint Committee on Reinforced Concrete

By DEAN PEABODY, '10
Assistant Professor of Applied Mechanics, Massachusetts Institute of Technology

AS the freshman follows the T. C. A. Bible, or the churchman his creed, so the designer and builder of concrete structures has come to depend upon the Joint Committee Report. From a modest beginning as "recommended practice" it has come to the certainty of "standard specifications." The Joint Committee is an affiliation of five committees appointed by the American Society of Civil Engineers, the American Society of Testing Materials, the American Railway Engineering Association, the American Concrete Institute, and the Portland Cement Association. The last report adopted, familiar to all present-day designers, is the "recommended practice" of 1916. In 1921 "tentative specifications" appeared which received animated and continued discussion. The 1924 standard specifications are a revision in light of this discussion of the 1921 report.



T-Beam

FIGURE 1

The report may be conveniently divided into two parts:

(a) the making of strong, economical concrete,

(b) the design of safe structures. There is also, as appendices, a collection of the specifications of the American Society of Testing Materials pertaining to concrete.

The Making of Concrete

Concrete is made of cement, aggregate, and water. The aggregate is usually divided into fine aggregate, or sand, and coarse aggregate, or stone. Satisfactory concrete in place in the structure depends on four operations:

(a) the selection of the materials,

(b) the proportioning of the mixture,

(c) the mixing of the concrete,

(d) its deposition.

Selection of Materials. Portland cement is selected by the standard specifications of the A. S. T. M. Tests are made for the time of set, for soundness, and for the tensile or, preferably, the compressive strength of a mortar mix with Ottawa sand. Optional tests are those for specific gravity and for soundness.

The fine aggregate is also selected by standard specifications which include a sieve analysis for variation in size, a decantation test for the maximum per cent of fine silt, loam, or clay, also a colorimetric test with sodium hydroxide for the presence of organic impurities. A strength test in tension or compression is made with a mortar mix for comparison with Ottawa sand.

The coarse aggregate, or stone, should be of clean, hard materials. It is also sieved to determine its grading.

The water "shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substance."

A careful following of these specifications ensures that the cement will be strong, that the concrete will set in a reasonable time, and that it will weather well, without those cracks and disintegrations that can be traced to unsound cement. The aggregate will be composed of particles strong enough to carry the load, and clean enough to give a good adhesion with the cement. A proper grading of sizes will make certain that a minimum amount of cement will be needed to bind together the artificial solid rock and give the requisite strength.

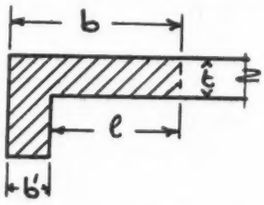
Proportioning the Mixture. If one enjoys lively argument with blows laid on alike by the contractor from his job and the theorist emerged from his laboratory, I can imagine no surer inciter than a new method of proportioning concrete presented to the proper annual convention. One must be sure of one's ground and a good fighter, for those who have previously proposed proportioning methods have been both.

The majority of concrete work done in the past has not been proportioned. The same mix, say a 1:2:4, has been required, no matter what the brand of cement, or grading of aggregate, or wetness of the mix. The early proportioning methods accepted as an axiom that, for a given cement and kind of rock particle, the strongest mixture was the densest. The ideal was a *solid* artificial rock, with no air or excess water spaces. Thus the 1916 report states that "extreme care should be exercised in selecting the aggregates for mortar and concrete, and careful tests made of the materials for the purpose of determining the quality and grading necessary to secure maximum density" of the rammed concrete.

Since then Messrs. Edwards and Young have advocated proportioning by "surface areas," figuring the surface areas of the aggregates and using some weight of cement for each 100 square feet of surface. They state that the compressive strength varies directly with this cement-area ratio.

Professor Arthur N. Talbot, Mr. Crum of the Iowa Highway Department, Taylor and Thompson's "Concrete, Plain and Reinforced" still maintain that their respective experiences in laboratory and field lead them to believe the best practical method to be that of proportioning by maximum density.

However, the method recommended in the 1921 and 1924 reports has been



Angle Beam

FIGURE 2

based on Professor Duff A. Abrams' "Design of Concrete Mixtures." The compressive strength, P, was said to be:

$$P = \frac{14{,}000}{7^x} \qquad (1)$$

After many field tests, the strength of average concretes is given as:

$$P = \frac{14{,}000}{9^x} \qquad (2)$$

where, x is the ratio of the volume of water to the volume of cement. Of course, x is affected by the consistency of the mixture, by the water used to hydrate the cement, and by the amount needed to wet the aggregate surfaces or that is absorbed. Thus x includes all the problems of size and quantities of material that other methods discuss. Professor Abrams supplies an equation for figuring x, which includes all these factors. However, for use in the field, the results of this equation are tabulated. All one needs to know is the range of size of sand and stone particles and the approximate strength desired, and the mix can be read. This table makes it a very simple matter to determine the mix.

The mix to specify on any particular job may be determined by one of three options.

Option 1. The engineer may make tests of the actual materials and determine the mix that gives the desired strength.

Option 2. The materials may be assumed to be of average quality and the mix determined by use of Professor Abrams' table. This table has given a needed and disconcerting shock to engineers by stating that concretes they had *assumed* to be 2000 to 2200 pounds per square inch strength were actually 1700 or 1800.

Option 3. The mix may be left to the discretion of the contractor; but his concrete shall be tested and must give the specified strength. This is the logical method, as the man who carefully selects his materials and watches the consistency, benefits by the ability to use a leaner and more economical mix. The disadvantage is the problem of what to do, if the concrete tests too weak. There it is, a part of the structure! Shall one pull down the building? After all, we are no worse off than in the past. We did not know the weak parts then, now we shall. A penalty clause for poor concrete would soon eliminate most of it.

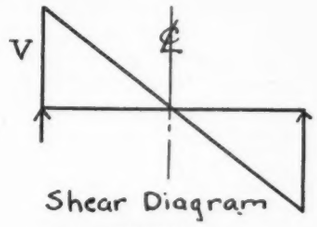


FIGURE 3a

The Mixing of the Concrete. The procedure to mix good materials and produce what is accepted as satisfactory concrete is well known. Machine mixing has largely superseded hand work. One must carefully measure the materials and must allow the batch at least a minute in the mixer. One should employ an automatic water-measuring tank and check the consistency by slump tests.

Depositing Concrete. Experienced men are the great requirement when depositing concrete. Experienced men will see that the forms are clean, that there is no separation of the materials as the concrete is chuted into the forms before it reaches initial set. They make sure that the concrete is rammed into place, and take care that it does not dry out prematurely. In cold weather the materials are heated and the structure protected to allow the concrete to set before freezing. Experienced men investigate accelerators, hardeners, and the precautions necessary in order to deposit under water, or in sea water, or to make water-proof and oil-proof concrete.

The Design of Structures

This portion of the report is devoted to the statement of accepted methods of design of beams, columns, footings, etc., and to specifying the allowable stresses. These stresses have been given in per cents of f'_c, the ultimate compressive strength of the concrete. Much more is now known of the physical properties of concrete and of the performance of structures under load than in 1916. The tendency is to increase the design stresses as the precision of design gains. The general theory for the design of structural members is covered in textbooks. This article can touch only on those methods which have been changed or added since the 1916 report.

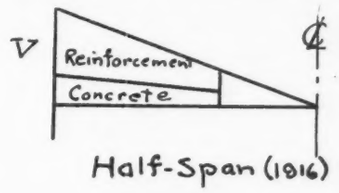


FIGURE 3b

Members in Flexure. Following a statement of general formulas and principles, maximum bending moments are given for continuous beams of equal spans carrying uniformly distributed loads. The conditions of restraint at the supports are more carefully defined and in some cases there is a reduction in the coefficient c in the equation:

$$M = c\,wl^2 \qquad (3)$$

where, M is the bending moment at a critical section
w is the intensity of the uniform loading
l is the span
c is the coefficient

The allowable fiber stresses are increased from 32.5% f'_c to 40% f'_c. The extreme fiber stress adjacent to the supports of continuous beams is likewise changed from 37.5% to 45%. The factor of safety is based on the Modulus of Rupture, of course, and is greater than these per cents indicate.

T-Beams. Whenever a beam and slab floor construction has been used, it has been allowable to figure part of the slab as the flange of the beam. The maximum width, b, which may be used must be less than:

(1) one-fourth the span
T-beam (Fig. 1)
(2) one-half clear distance to next beam
(3) $l = 8t$, or $b = b' + 16t$
Angle-beam (Fig. 2)
(1) one-tenth the span
(2) same as T-beam
(3) $l = 6t$, or $b = b' + 6t$

Shear. Beams with well designed systems of reinforcement may now carry a maximum shearing stress of 12% f'_c. This is 100% greater than the 1916 value and may be regarded as a result of the tests made during the war by the Bureau of Standards and the Shipping Board.

Diagonal Tension. "When a reinforced concrete beam is subjected to flexural action, diagonal tensile stresses are set up. A beam without web reinforcement will fail if these stresses exceed the tensile strength of the concrete. . . . For the composite structure of reinforced concrete beams, an analysis of the web stresses, and particularly of the diagonal tensile stresses, is very complex. . . . Under these circumstances, in designing, recourse is had to the use of the calculated vertical shearing stress, as a means of comparing or measuring the diagonal tensile stresses developed, it being understood that the vertical shearing stress is not the numerical equivalent of the diagonal tensile stress, and that there is not even a constant ratio between them."* Concrete beams require web reinforcement if the shear stress is greater than 2% f'_c for unanchored, or 3% f'_c for anchored longitudinal steel. The shear diagram for a beam with a uniformly distributed load is shown in Fig. 3a. For the purpose of figuring resistance of the web to diagonal tension the division of the shear by the 1916 report is shown in Fig. 3b. The division by the 1924 report is also given in Fig. 3c. The assumption of shear at the section of figured zero shear makes allowance for the possibility of the application of concentrated loads.

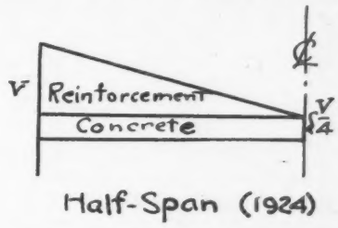


FIGURE 3c

Web Reinforcement may consist of
(1) Stirrups
(a) vertical
(b) inclined 30° or more with the longitudinal steel
(2) Longitudinal steel bent up at an angle of 15° or more

* 1916 report

(*Continued on page 302*)

The Evolution of the Ship

Briefly outlining the course of development in sail and steam

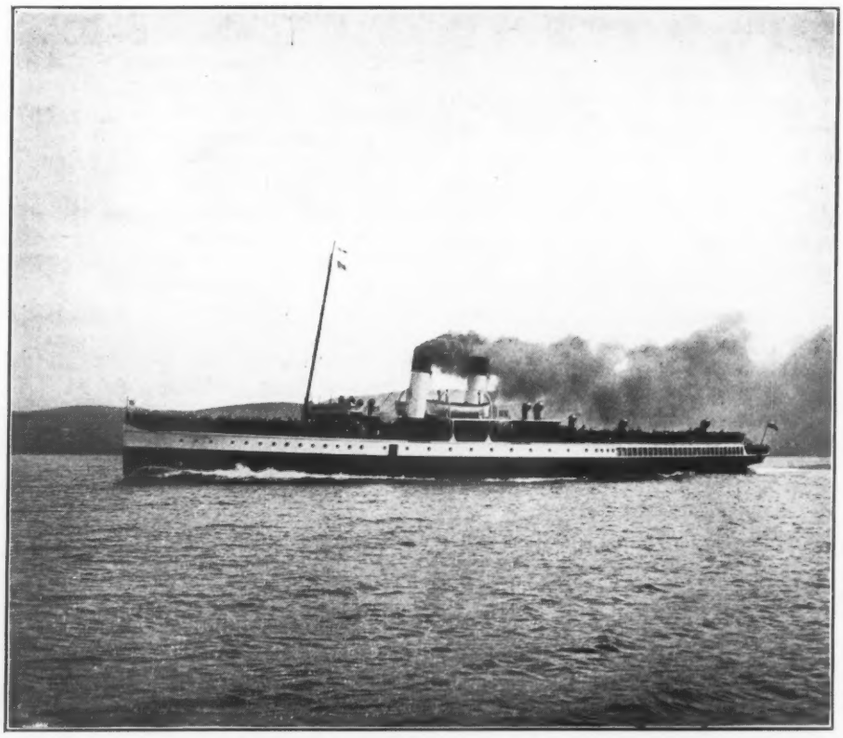
By J. R. JACK

Professor of Naval Architecture and Marine Engineering; in charge of the Department, Massachusetts Institute of Technology

AS the science of engineering is based upon natural laws, the engineer has as much need to study nature as the biologist has, and such study shows a curious similarity in the evolution of plant and animal life to the complicated production of engineering science. When Darwin and Wallace worked out the theory of evolution and survival of the fittest, they explained not only the main facts of biology, but also the main methods of the engineer, and the later discoveries of De Vries have still further deepened the similarity. Darwin thought that nature progressed by infinitely slow but continuous stages, constantly improving at each step. According to De Vries, the real changes take place more abruptly, nature appearing to progress slowly for a long time, and then suddenly making a jump forward to something distinctly better than anything that had been before, and that this advance was consolidated and made permanent. In the evolution of shipping we see the same things happening; while progress is continuous, the rate may be very slow for a number of years and then something almost revolutionary will take place, and a new start will be made on the higher plane. Curiously enough, nature does not always appear to move forward; sometimes, indeed, she might almost be considered to take a step back, and man has quite unintentionally copied her retrograde movement, much to his discomfiture.

Just when the first ship was constructed will remain a mystery, but man's need for water transportation is as old as man himself, and probably that curious creature whom we call "paleolithic man" made use of floating tree trunks to assist him in escaping from the too pressing attentions of the monsters of his day. The technical properties of a log, however, are extremely poor, and as a means of transportation, it would leave very much to be desired, but probably any improvement would be beyond the skill of the "man" himself. In the later stage, however, neolithic man (who was a real man) tackled the problem with considerable intelligence, and by means of his sharpened flint axe, he trimmed the log to something of a boat-shape and hollowed it out by charring the inside with hot stones. About twenty-five years ago, a boat of this type was unearthed on the banks of the Clyde, in Scotland. It was in a little dock, the sides of which were piled with small tree trunks, and the whole was in a wonderful state of preservation. The site of this find was within two miles of a shipyard, in which was built the first steel vessel to cross the Atlantic, the first turbine-propelled merchant ship and the first geared turbine torpedo-boat destroyer. The limitations of such a method of construction are obvious, but it is a long jump to the next surviving ship, which is now safely housed at the University of Christiania, in Norway. This is a beautifully constructed little vessel of the Viking type, built clinker fashion, and with lines as graceful as those of a modern yacht. This simple method of construction was only suitable for comparatively small sizes, and as the needs for larger vessels became more dominant, the Carvel system of construction was adopted and gradually improved over many centuries. It reached its zenith about the time of the famous clipper ships. Progress in shipping, more than in any other human activity, tends to become general over the known world, as the ships are constantly moving from place to place, and each improvement is shown in the ports of the world, and while local conditions may sometimes leave some mark on local types, it is less so in shipping than in almost any other work of man, and where it has occurred most strongly has been where artificial restrictions have obtained, especially when those consisted of protective laws. Such was the case in the olden days with the British trade to the East, which was strictly preserved for British vessels. Being protected from foreign competition, the British ship builder and ship owner practically went to sleep, and progress ceased, so that it was no uncommon thing for the ship to take more than a year on her voyage to China. When the trade was made free to the world, it at once attracted competition from other nations, and American ship owners entered the trade with a new type of vessel. They had previously been interested in the fast sailing vessels on the China coast. A model of one of these had been brought to America, and her fine lines were the inspiration of the clipper ships. This model is now one of the cherished possessions of the Institute, and a feature of the Clark Collection. The competition of these fast ships soon left the British ship owner badly beaten, and he had to do some-

(*Continued on page 310*)



THE FIRST SHIP TO SUCCESSFULLY USE STEAM TURBINES

S. S. King Edward of The Turbine Steamers, Limited. It is now being used for pleasure excursions on the River Clyde.

The Mississippi River Delta

An unsolved problem in steam erosion

By J. H. ZIMMERMAN

Assistant Instructor, Department of Mechanical Engineering, Massachusetts Institute of Technology

THE problem of maintaining an open mouth for the Mississippi River is one dealing with natural phenomena seldom encountered in engineering practice. Great lumps of mud make their appearance over night. Massive sand waves traveling slowly down the several passes of the river at its mouth have caused a shoaling of as much as twenty feet in twenty-four hours. Segments of the narrow river banks cave in, are washed out in a few minutes and threaten to open a shorter path for the tons of water rushing to the Gulf of Mexico. These and lesser difficulties necessitate the constant guidance and deflection of the river waters in the work of keeping the channel navigable from the gulf to the city of New Orleans. Since the official opening of the channel to navigation in 1879 a corps of men has been employed by the U. S. Engineers to carry on this work of maintenance. The present problem is that of increasing the depth of the channel to accommodate the rapid growth and consequent greater draft of the ocean going vessels. Much could be written on the methods employed in coping with the various difficulties encountered in this work, but it is felt that a brief survey of the earlier efforts to clear the mouth of the river would not be without some interest.

For ninety miles below New Orleans the Mississippi River is an excellent waterway and harbor, and it is probably safe to assume that ships will never outgrow this end of the channel. However, at the Head of Passes, as a glance at the map of the Delta will show, the river divides into three passes; Pass a l'Outre, flowing to the east, of no practical commercial value; South Pass, the narrowest of the three, used as a ship channel for almost fifty years and the main entrance to the river from the Gulf of Mexico, and Southwest Pass, a fine natural waterway of little use commercially in the past because of shoalings at its head and mouth. By means of this delta formation, the river has projected itself far out into the gulf, as is also indicated by the map.

A French map, drafted in 1722, shows that at that time Pass a l'Outre branched about a mile or so from its mouth, and that the South branch had a minimum thalweg depth of fourteen feet with but slight shoaling at the mouth. This map also shows two converging lines which would seem to be a suggested location for jetties, but as these would antedate the oldest known jetties, those at the mouth of the Dwina River in Russia, it is probable that they were added at some later date. The map record shows that some twenty years later this channel was rendered useless by shoaling thruout its length and at present it is in an even farther advanced stage of decay as far as navigation is concerned. Of the historic old settlement "Balize," which once flourished at its mouth, there is left only an iron tomb and a few traces of brick work.

Efforts were made to deepen this first pass, but without success. The other fork of Pass a l'Outre was used for a short while, but this, too, was rendered practically useless by shoals, so early in the nineteenth century all traffic was piloted thru the deeper Southwest Pass. These were the days when clipper ships were towed to sea by steam tugs. Many a clipper has been loaded to draw two or three feet more water than was known to exist on the bar at the mouth of Southwest and has then been sledded thru or over the bar by main strength. Quite naturally mishaps and delays were frequent and very often large fleets of ocean vessels would be held up for days by the blocking of the channel. Dissatisfaction resulted and relief was demanded of the government. Various processes of dredging, scouring, etc., were tried, but only temporary relief resulted, and the dissatisfaction with the condition of the channel increased. More serious attention was given the matter by the authorities and numerous projects, most of which involved the construction of new canals, were presented to Congress by the Army Corps of Engineers, the Coast Survey, the State Engineers of Louisiana and private companies. The result was confusion and inability to choose what seemed to be the most feasible plan and it was during this controversy that James B. Eads became interested.

As a diver and constructor of many years' experience on the Mississippi, Mr. Eads had gained a wide knowledge of the river. His bridge across it at St. Louis was an engineering triumph though to him a financial failure. He had made a close study of erosion by current and he favored the theory of a natural mouth for the river which should be kept open by jetties. Eads was a man of force and somewhat of a plunger, so in 1874 he presented his ideas to Congress. He proposed to build jetties at the mouth of Southwest Pass at his own risk and expense, to be paid only if the desired result was accomplished. He was first looked upon as a meddler and experimenter and his plan met with no sympathy. He was even accused of being hired by the railroads to ruin the river for navigation. His persistency and his bridge, however, finally brought a decision to send a commission to Europe to investigate existing jetties. Eads accompanied this commission of seven government engineers. They studied the jetties at the Sulina mouth of the Danube in Roumania, which was analogous to the mouth of the Mississippi in many respects, and jetties in Russia, Holland, Germany and Denmark. Upon their return they recommended the jetty plan, but for the South Pass instead of Southwest Pass because it would be cheaper.

Eads was disappointed in the change to South Pass from his plan and he fought for its adoption as originally presented, but the Senate insisted that the work be done at South Pass. A bill to this effect was passed in 1875.

The jetties were completed by Eads one year later and steamers drawing fifteen feet of water passed easily through the pass. The jetties were an assured success. A few years later the channel was officially opened with a navigable depth of twenty-six feet. The twenty years of maintenance contracted for by the government, plus the periods when there was any deficiency in channel, ended in 1901, and the total payments made to James B. Eads and his heirs aggregated about eight million dollars.

Since the expiration of the Eads contract, the United States has maintained the South Pass channel through the Engineer Corps settlement at Port Eads. By more dredging and further expenditures for mattress sills, wing dams, etc., the navigable depth has been increased to thirty-two feet or more, and except for limitations in its size, South Pass is still an excellent ship channel. However, the natural bar advance together with the peculiar mud lump formations have rendered maintenance more difficult and the approach channel has shifted so far eastward that vessels are obliged to make a sharp turn when entering the mouth of the jetties. The volume of discharge has been increased over 60 per cent and the quantity of sediment deposited just outside the jetties has increased proportionally.

The increased difficulty of maintenance together with the limitation in size of South Pass led to the adoption

(*Continued on page 308*)

The Powell Leverage Motor

A New Principle in the Construction of Internal Combustion Engines

By VERNER J. SWANSON
In charge of engineering, The A. L. Powell Company of Oklahoma, Quapaw, Oklahoma.

THE first difference between the Powell Leverage Motor and any orthodox engine, apparent to the eye on examination, is that the piston is not coupled directly to the crank shaft but has a compound lever between the piston and the crank shaft. There are other differences in construction which are revealed only on close examination.

In performance, the Powell Leverage Motor comes more nearly than any conventional engine to fulfilling the ideal conditions essential to the utilization of the greatest amount of heat and energy developed in an engine, as laid down by the French engineer, Beau de Rochas. These conditions as stated by de Rochas were:

First—There should be the largest cylinder volume with the smallest exposed surface.

Second—Maximum piston speed.

Third—Highest possible pressure at beginning of expansion.

Fourth—Great possible expansion.

The peculiar construction of the Powell Leverage Motor gives nine outstanding advantages.

A long piston stroke gives turbulence to the fuel mixture in the cylinder, moving the gases to the hottest portions of the cylinder and keeping the walls of the cylinder clean. It also gives increased flexibility.

In the Powell Leverage Motor the piston travel is exactly double the distance of the crank shaft stroke; a 4 inch crank shaft stroke giving a piston travel of 8 inches. This long piston stroke is beneficial in many respects, notably for the following reasons:

(a) Turbulence speeds up the combustion process, by mechanical distribution of the flame following ignition and seemingly gives the mixture more than one firing point. Turbulence also gives a scouring effect which results in cleaning the cylinder walls of the combustible mixture which may not be burned on account of its temperature never being raised high enough to bring about combustion. There is also a vaporizing or atomizing effect which may result from a high degree of turbulence.

There is also a tendency to move the gases over the three hottest portions of the cylinder (exhaust valve, piston center, sparkplug), so quickly that the gases do not cause preignition or increase the chances of detonation.

(b) Flexibility of an engine is usually dependent upon the length of stroke, valve timing, and size of valve ports. It has been found in testing conventional engines of various stroke-bore ratios, that the longer stroke engines are more flexible than the short-stroke engines.

The piston speed of a Powell Leverage Motor is double that of a conventional engine with the same sized crank shaft and making the same number of revolutions per minute, giving increased thermal efficiency, higher compression and hence increased horse power and torque and greater fuel economy.

Thermal efficiency is heat efficiency and the degree to which an engine possesses thermal efficiency depends on the extent to which it converts the degrees of heat of the combustible mixture into foot pounds of work.

In studying the movements of the Powell Leverage Motor on a plotted motion diagram, it is manifest that the piston on the compression stroke has an unusually fast speed on the last 90 degrees travel of the crank shaft. This rapid motion allows the use of a high compression which is conducive to increased horsepower, torque and fuel economy.

While high piston speed increases the flexibility of any engine, this feature in a conventional engine shortens its period of usefulness through strain which cannot be avoided because the rest of the engine must travel at a speed corresponding to that of the piston. In the Powell Leverage Motor, the effect of this piston speed is not more rapid motion of other parts but more power with the same amount of fuel.

The small diameter of the piston in the Powell Leverage Motor makes possible a light piston, tends toward high compression, shortens the nor-

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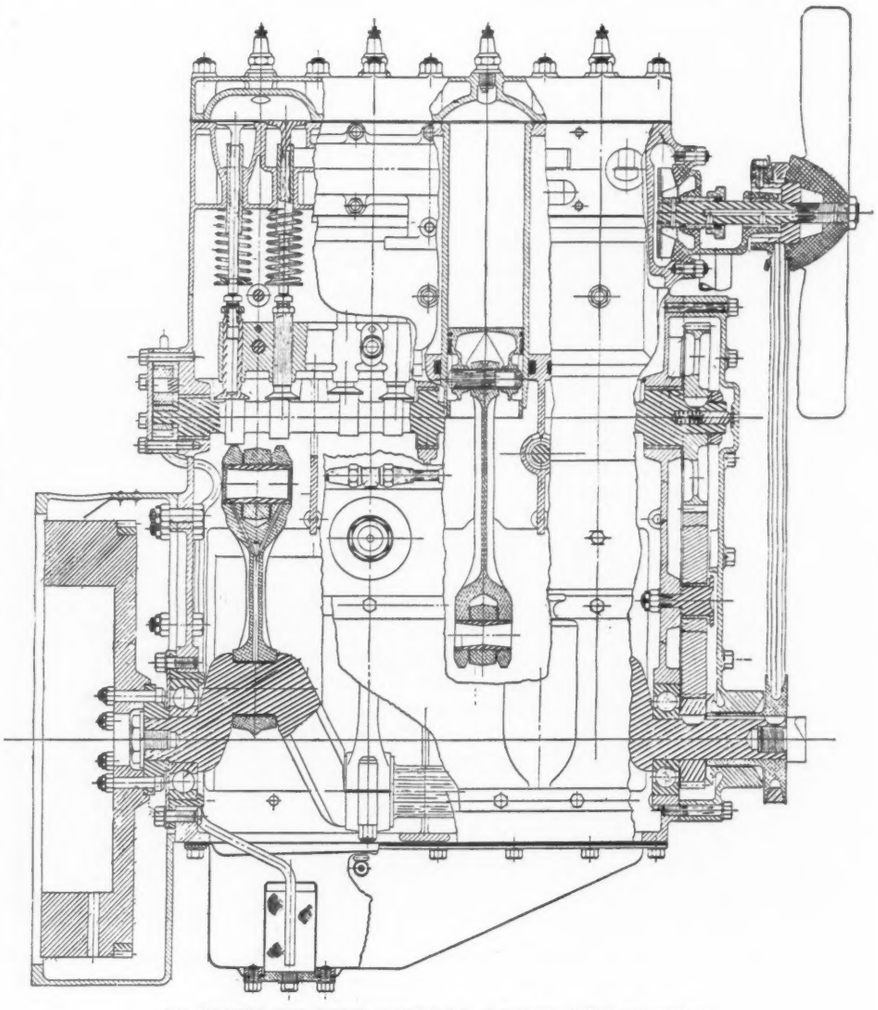


SECTION OF THE POWELL LEVERAGE MOTOR

Recent Books

This department conducted in co-operation with the Technology library

BIOLOGY

General Cytology. A textbook of cellular structure and function for students of biology and medicine. Edited by Edmund V. Cowdry. Chicago: University of Chicago Press, 1924. 754 p.

This book, edited by Dr. E. V. Cowdry, of the Rockefeller Institute for Medical Research, in New York City, consists of eleven chapters, written by as many authors, each one of whom is distinguished in a particular field of biological research.

The list of the authors on the title page looks like a section from the Directory of the Marine Biological Laboratory, situated at Woods Hole on the south shore of Cape Cod, where biologists like to congregate in the summer to pursue their various hobbies unimpeded by the demands of students.

The title of this book may need explanation for the general reader. "Cytology" is a comparatively new name for an old subject; namely, the study of the minute structure of cells —those units which form the building stones of animal and plant bodies. Formerly they were spoken of as the ultimate units of living matter, but now, like the atom, they are subdivided into smaller units which seem to be equally alive.

The introduction to this book is written by Professor Edmund B. Wilson, a most distinguished American in this field of study, who gave the first Sedgwick Memorial Lecture, under the auspices of the Department of Biology and Public Health, at the institute two years ago. The first chapter after the introduction is by a graduate of the institute, Dr. Albert P. Mathews, of the Class of '92. This chapter will be of value to persons interested in biochemistry. It deals with the general aspect of the chemistry of cells. The next chapter, by Dr. M. H. Jacobs, on the permeability of the cell, deals with the physical chemical properties of living matter. Perhaps the most fascinating chapter of the book is by Robert Chambers of New York City, in which he describes the very remarkable results obtained by the actual dissection of cells under the microscope. By this means, elements of the cell, which formerly could only be seen in thin sections, that had been prepared in various ways and stained to bring out their structure, can now be seen as separate bodies and can be pushed about and torn apart, as one might examine the parts of a garment with one's fingers.

A few years ago a method was invented at the Zoölogical Laboratory at Yale University by which living animal cells may be grown outside the body. This book contains a chapter by Dr. and Mrs. W. H. Lewis which describes the results obtained by studying cells in this manner.

The remaining chapters in the book treat of the subjects of perennial interest, fertilization, differentiation, and heredity, by Professors Lillie, Conklin, McClung, and T. H. Morgan, all of whom are well known authorities on these subjects. The book is not intended for popular reading, but anyone interested in these subjects can obtain from it much of interest and value.

R. P. BIGELOW.

AERONAUTICS

An Introduction to the Economics of Air Transportation. By Thomas H. Kennedy. New York: Macmillan Co., 1924. 154 p.

This little book contains the essential facts to show the status of air transportation today both in this country and in Europe. Following summary accounts of the historical and technical development of aircraft, there are chapters on the U. S. Air Mail Service, the U. S. Army Model Airway, present-day commercial air service, projected air lines, and European air transportation. As its title indicates, the book is only an introduction to the economics of a transportation development still in its infancy, but as such it will be useful for reference.

CHEMISTRY

Eminent American Chemists. A Collection of Portraits of Eminent Americans in the Field of Chemistry from the Earliest Days of the Republic to the Present; together with Short Sketches of the Work of Each. Compiled and edited by D. H. Killeffer. New York: Pub. by the author [1924]. 33 port.

This volume, amply described by its sub-title, might well be studied by students of chemistry to whom the names of great chemists are names only. Here they will come face to face with excellent likenesses of such men as Priestley, Rumford, Gibbs, Noyes, and others, and will find enough descriptive text to fix in the mind the place of each in the chemists' hall of fame.

CIVIL ENGINEERING

An Introduction to the Practice of Civil Engineering. By E. E. Mann. London: Macmillan Co., 1924. 296 p.

Author has found that most graduates of engineering schools come to their first job with plenty of mathematics, but lacking knowledge of the ordinary routine work of an engineer's office. This little book of "engineering commonplaces," as the author puts it, is intended to aid them to understand better the actual practices in the midst of which they find themselves. Although written with English conditions in mind, it contains much of value to graduates of American technical schools.

ECONOMICS

Adjusting Immigrant and Industry. By W. M. Leiserson. New York: Harper, 1924. 356 p.

Professor Leiserson has devoted many years to the intimate study of labor conditions and has served on numerous industrial arbitration boards. No one, therefore, could be better informed on the problems that arise out of the contact of the immigrant with American industrial conditions. This volume sets forth the present progress being made by employers, employees, the Federal and State governments, and various societies to solve these problems to the best interest of everyone concerned. It is a sane and readable discussion which every student who expects to deal later on with laboring groups ought to read.

SANITARY ENGINEERING

Transactions of the International Conference on Sanitary Engineering, London, 1924. London: The Institution [1924]. 383 p.

This conference, said to have been the first ever devoted solely to sanitary engineering, was so successful that it is likely similar conferences will be held in future years. Several well-known American engineers like Eddy, Hatton, and LePrince contributed papers or shared in the discussion. For the most part the papers dealt with sanitary administration, the progress of sewage disposal, the value of activated sludge as fertilizer, the disposal of industrial wastes, the purification of water supplies, and the control of yellow fever and malaria.

The Engineering Field

Excerpts from the leading professional and trade journals

New British Airships. Vickers & Co. have signed a contract for the construction of an airship of 5,000,000 cu. ft., more than twice the size of the Los Angeles, which is the first of two such vessels which are to be built under a recent Government decision to redevelop airships in Great Britain.

Approximately, the cost to the Government for the first airship will be £350,000, provided the airship completes its trials. Three years are allowed for the construction, and under the contract it must be delivered to the Air Ministry by September, 1927. Its length is 695 ft. and its diameter at the point of greatest girth is 132 ft. The contract specifies that the structure and other fixed weights must not exceed ninety tons.

Budgeting on a range of 2,500 miles, there is available as space for a paying load weight of 120 passengers and ten tons of freight or mails. This figure is arrived at after allowing a 50 per cent reserve for fuel and oil.

Thirty two-berth cabins are provided along the sides of the vessel, and in addition there is a smoking room, a lounge big enough to dance in, the usual accommodation for kitchens and the quarters for a crew of forty.

The passenger quarters are completely isolated from the rest of the ship, not only by gas-tight walls, but by an air space through which free air will constantly be circulating, so that the fire risk from a passenger's carelessness or ignorance is reduced to a minimum. Hydrogen is to be the lifting medium, but gasoline will be eliminated in favor of the Ricardo kerosene and hydrogen fuel system. So far, the system has been experimented with only on small engines, but a full size power unit of 550 h.p. is nearing completion and will be tried out shortly. Seven of these units are to be used in the airships, giving a total energy of 3,800 h.p., for an expenditure of little more than a half ton of fuel in an hour.

A cruising speed of 70 mi. hr. is estimated, and the reason for basing the financial calculations on a range of 2,500 mi. is that this distance is approximately that of four stages between here and Australia.

The second ship, which will be built in the airship works at Cardington, will have a framework built of stainless steel, as against duralumin used in the sister airship as well as in all other rigids so far.

The total lift is to be 155 tons, with a disposable load of 75 tons, and 20 tons should be available for passengers and goods on the trip of 2,500 mi. to Egypt.

The approximate over-all length is 720 ft. and the maximum diameter 130 ft. The maximum height is to be 140 ft. Crude oil will be burned in seven engines of 600 h.p. each, instead of gasoline.

A maximum speed of 50 miles per hour is estimated and 100 passengers will have their accommodations spread over two decks.

While the make of the engines to be used is not given, it is worth noting that the Beardmore firm of Glasgow, Scotland, has for some time been conducting experiments with a heavy oil engine for aircraft use. In a lecture held before the Royal Aeronautical Society, A. E. Chorlton stated that this company had recently produced six- and eight-cylinder engines of the vertical type, with 6 9/16 in. bore and 12 in. stroke. The normal speed is 1,200 r.p.m., at which the six-cylinder unit develops 800 h.p. and the eight-cylinder unit 1,050 h.p. The weight of the two engines is 1,825 and 2,350 lbs. respectively, or approximately 2¼ lbs. per h.p. An engine of the same type, but fitted with cylinders of smaller bore and with a fuel injection pump, had been made to run on crude oil, but it gave less power than the gasoline engine.—*Aviation.*

The Electrification of the Virginian Railway includes an 11,000-volt trolley line on steel structures over 134 miles of main line track and a total trackage of 231 miles, including double track, yard tracks and side tracks; a 50,000-kilowatt steam generating plant at Narrows, Va.; an 88,000-volt transmission line carried on steel towers, largely across country on independent right-of-way; seven transformer stations to step-down the current to 11,000 volts for the trolley wire and 12 electric locomotives of three units each, together with repair shops and inspection facilities. Each locomotive will weigh 625 tons. Two locomotives (one acting as pusher) will take a 6,000-ton coal train up Clark's Gap Hill at 14 miles per hour, and one locomotive will take a 9,000-ton train from Clark's Gap yard to Roanoke at 14 and 28 miles per hour, the lower speed being on the grades. The power plant, transformer stations, transmission line and distribution system will have a capacity for handling an annual coal tonnage of 12,500,000 tons, and the 12 electric locomotives will be sufficient to handle 8,000,000 tons annually.

Timing the Air Races. Accuracy and exactness in checking and timing the flights of planes in air races are essential if the speed and efficiency records of these ships are to be officially recognized. The chronograph is an instrument which records and prints the exact time to the one hundredth part of a second.

This instrument, perfected by Odis Porter of Indianapolis, official timer for the race meet, is the only one of its kind in the world.

Aiding materially in the recording of time made by a plane in each lap over a race course is the "semi-automatic trip," an invention of B. Russell Shaw.

As a plane comes in sight of the timer, the sighting device on the automatic trip, which revolves on a table, is trained on it and follows the ship until the sighting instrument strikes the exact center of the table, directly in front of the observer. When this point is reached, the instrument automatically releases the hammer on the chronograph, which prints the time to the fraction of a second.—*Aviation.*

Oil from Coal. Dr. Rittman, of the Carnegie Institute of Technology, advocates the recovery of oil from the entire annual coal yield of the United States, and solid residue to be used to make power. "By-product plants should be an integral part of all central power plants, thereby assuring a gasoline supply for automobiles, eliminating smoke and making a cheaper electrical power," he is quoted as saying. Dr. Rittman estimates a possible recovery of 8,000,000,000 gallons of oil per year by the adoption of such a course. —*Power.*

Pipes Lined with Concrete by Machine. With the object of avoiding incrustation, it has been American practice for some years past to line metal water pipes with a thin coat of cement, applied by means of a brush, cement gun, or by hand.

During the course of some experiments in England, it was discovered that the machines used in the centrifugal-casting process of making concrete pipe could also be used for lining steel and cast iron pipe, the resulting coating being very dense, and attached very firmly to the inside of the pipe. In large pipes, the lining is made about one-half inch in thickness, but this may be increased to 1 inch where desired.

Using this process, new pipes, which are considerably lighter than standard cast-iron pipes, have been made in sizes ranging from 4 to 72 inches in diameter.—*National Sand and Gravel Bulletin.*

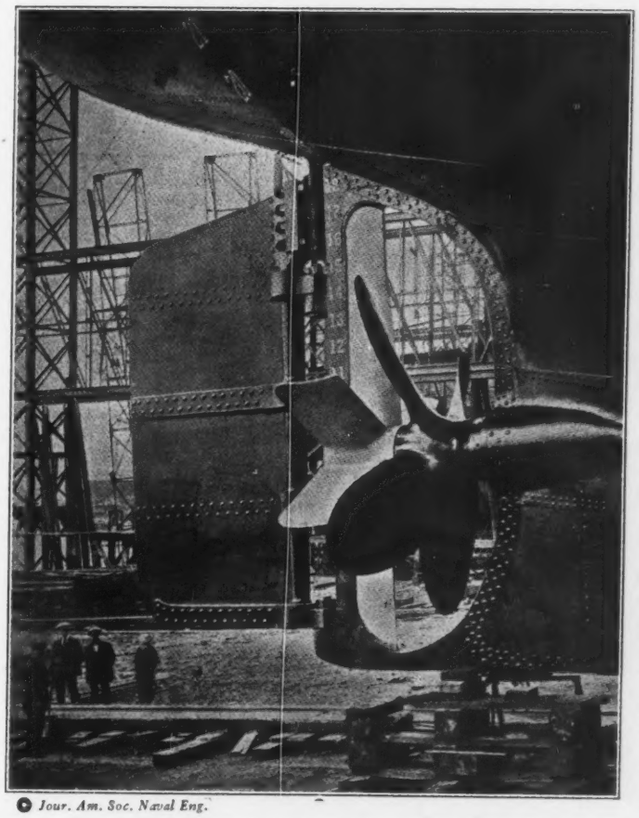
Sea Sled-Type Barges. Four barges 97 feet long by seventeen feet beam, with sea sled-type hulls have been built for the Philadelphia Paper Company. This type of hull was adopted to minimize wave formation in narrow canals where previously the speed of barges had been limited, not by the power necessary to tow them, but by the washing out of banks. According to reports from the owners, the sea sled-type barges not only have permitted towing at higher speeds, but have shown a very substantial reduction in power required over the regular type barges for the maintenance of a given speed.

The sides of the boat are practically parallel forward and end in a wide bow. The bottom is of inverted V section throughout, the chines being lower than the keel and the included angle at the keel varying from end to end, the forward section being sharpest. Aft, the keel is lowered to give almost flat sections so that the capacity of the hull is not substantially reduced from that of a scow shap of the same dimensions. Forward, the waterlines of both sides and bottom, instead of being curved inward toward a vertical stem, are curved outward, the effect of which is designed to practically eliminate the bow wave.—*Marine Engineering and Shipping Age.*

Roller Bearings for Trolley Cars. In the increasing sharpness of the competition between the trolley car companies and the bus lines, the former have found that the reduction of noise is imperative. Toward this end, there have been experimented with new light-weight trucks employing cushion wheels, helical gears, some magnetic and some automobile-type drum and band brakes, and roller bearings. These roller bearings, of Hyatt type, are particularly important. For a period of several years, test installations have proved practicable and very successful in reducing friction and eliminating noise.—*Electric Traction.*

Three-Blade Rudder. The first seagoing installation of the Flettner three-blade rudder has been made. It is on the motorship Therese Horn, which is thereby enabled to turn from a maximum speed straight ahead course, through a circle of a diameter less than two lengths of the ship, and to come out of this turn to straight ahead in 20 seconds. It does not transmit wave shocks to the vessel, insuring steadiness of course in a rough sea, and avoiding stresses liable to break the rudder or its shaft.—*U. S. N. Inst. Proceed.*

Effective Contra-Propeller. The first contra-propeller to be fitted to a British motorship, namely the Silverlarch, a 400-foot, 8,400-ton dead weight vessel, shows considerable economy in operation. The installation was made wholly by welding. The blades function to get the rotation out of the water acted upon by the propeller, converting this rotational energy into propulsive force. A similar installation on a tug increased the effective thrust of the screw by 50 per cent. The contra-propeller is shown in the illustration as the lighter-colored set of blades welded in place immediately behind the propeller.—*The Marine Engineer and Motorship Builder, abstracted by Journal of Am. Soc. Naval Engineers.*



Jour. Am. Soc. Naval Eng.

STAR CONTRA-PROPELLER OF THE MOTORSHIP "SILVERLARCH"
This device converts the energy of the rotating water in the propeller race to useful propulsive force.

New Naval Air Cruiser. A metal flying boat, capable of making 2,500 miles in non-stop flight, has been contracted for by the Navy Department with the Boeing Airplane Co., of Seattle, Wash., and is now under construction, the design having been approved by the Bureau of Aeronautics.

The new seaplane, known as type PB, will incorporate several departures in aircraft construction as practiced in this country, an interesting feature being the placing of two Packard engines in tandem so that when in the air one of the power plants may be shut down for minor adjustments without landing. This arrangement is also expected to make for economy of fuel consumption at cruising speeds. The plane will for the most part be constructed of duralumin.

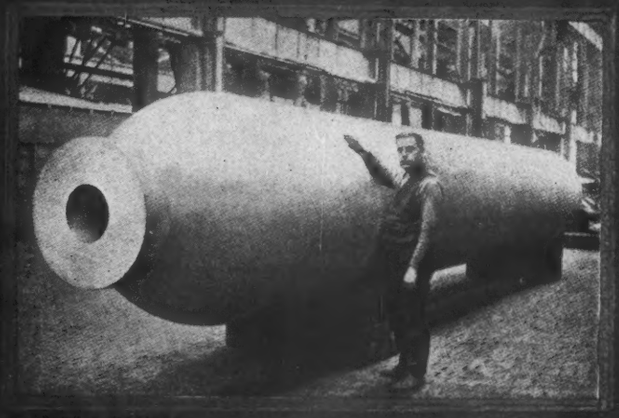
An interesting light is thrown on naval aircraft development when the characteristics of the new PB seaplane are compared with those of the historic Navy-Curtiss NC type which made the first trans-Atlantic flight in 1919. The weight of the NC type was 28,000 lbs. and its range was in the neighborhood of 1,600 miles. The Navy PB has a full load weight of 24,000 lbs. and a range of nearly 1,000 miles greater. The NC's wing span was 126 ft. The PB wing span will be 87 ft. 6 in.

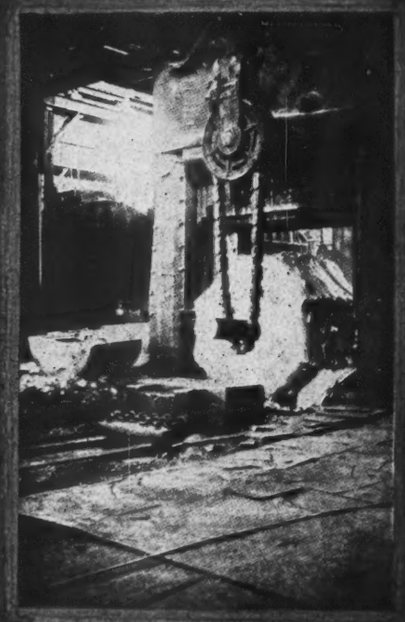
Of the total weight about 10,000 lbs. will be carried as fuel, representing nearly 1,700 gals. of gasoline. Five men will compose the crew of the new air cruiser. There will be two pilots, two mechanics and a radio operator. The two engines will develop 1,450 h.p. at 1,800 r.p.m.

An interesting parallel to this development is under construction by the Navy Department in the so-called PN9. The latter is an all-metal flying boat which is a development of the F5L type. The PN9 is designed for a cruising range of 2,200 miles and will carry approximately the same number of men in the crew as the Boeing type.

Snow Removal by Steam. New methods recently used.

The device with which this task is accomplished is very simple, consisting as it does of a system of pipes and nozzles through which steam is blown in front of the locomotive, melting the snow and clearing it effectively from rails and cross ties.—*Railroad Data.*





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OPEN HEARTH INGOT WEIGHING 262000 POUNDS

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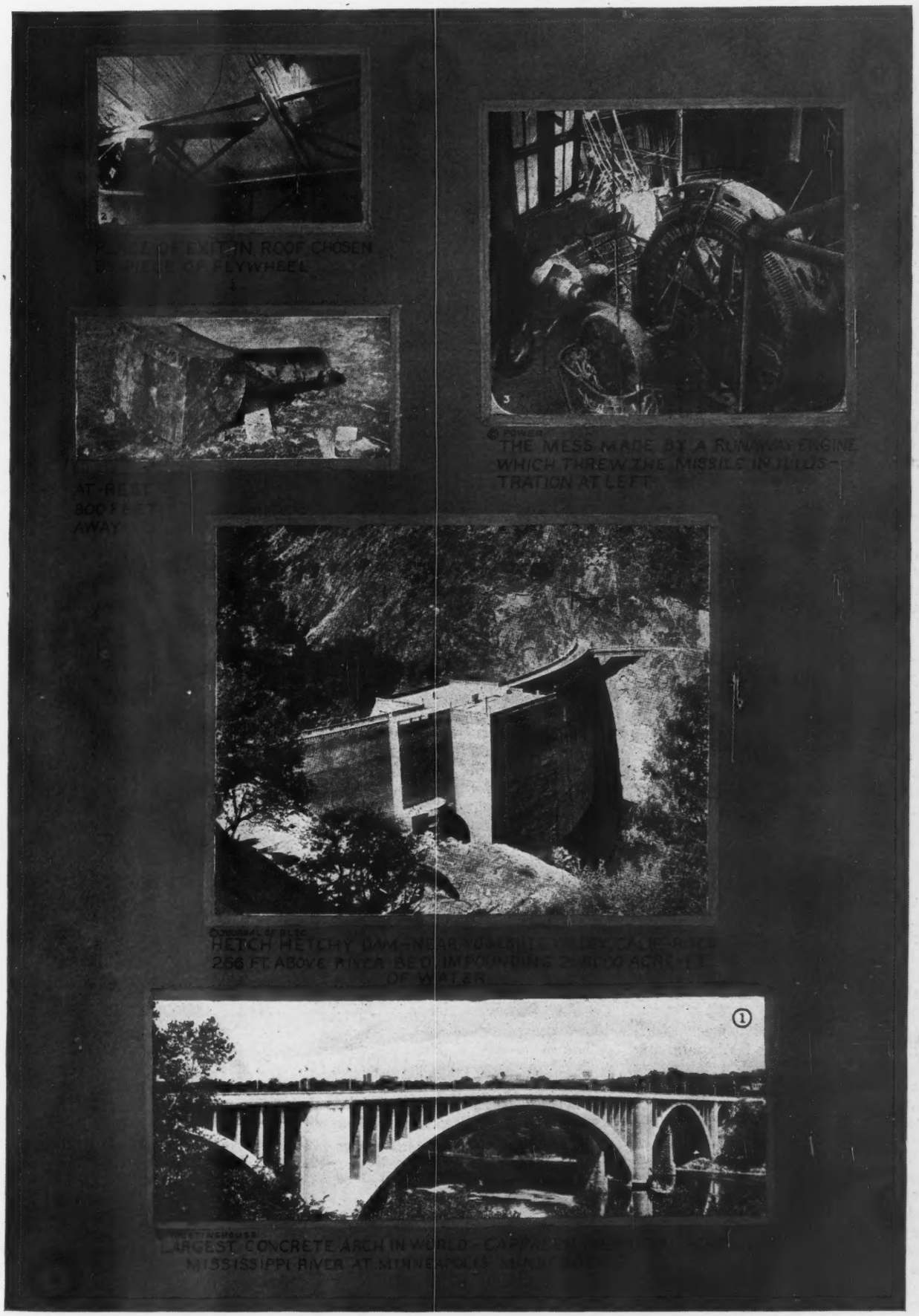
THE NAVY'S LARGEST SUBMARINE - A CRUISER ABLE TO KEEP UP WITH THE FLEET

© DUPONT MAGAZINE

DYNAMITE AS A SCULPTOR'S TOOL - HASTENING PROGRESS ON THE CONFEDERATE MEMORIAL BEING CARVED ON THE FACE OF STONE MOUNTAIN, GA.



THE MESS MADE BY A RUNAWAY ENGINE WHICH THREW THE MISSILE IN ILLUSTRATION AT LEFT

HETCH HETCHY DAM—NEAR YOSEMITE VALLEY, CALIF.—RISES 256 FT. ABOVE RIVER BED IMPOUNDING 24,800 ACRE-FT. OF WATER

LARGEST CONCRETE ARCH IN WORLD—ACROSS MISSISSIPPI RIVER AT MINNEAPOLIS

Professional Notes

Activities of the Undergraduate Engineering Societies

ELECTRICAL ENGINEERING SOCIETY

The first meeting of the Electrical Engineering Society for this year was held October 23, at which Dr. V. Bush of the Electrical Engineering Department spoke on the subject of the "S" Tube and gaseous conduction. In the first of his talk Dr. Bush spoke about the general principles of the conduction of electricity through gases according to the classical theory. In the latter part he spoke about the "S" tube, which is a rectifier of electric currents based upon the principles of gaseous conduction as differentiated from thermionic or electronic conduction. In the latter device the current is transmitted through a vacuum by a stream of electrons emitted from an incandescent filament. The "S" tube brings about one-way conduction between two cold elements in a gas-filled tube surrounded by an intense magnetic field. Dr. Bush's talk was illustrated by a number of interesting experiments. In closing, the speaker stated that in his opinion one of the greatest fields for advance in the future of electrical engineering would be in gaseous and electronic conduction.

The second meeting of the Society was held November 20, the speaker being Mr. E. W. Davis, '13, of the Simplex Wire & Cable Company. Mr. Davis spoke on the manufacture and use of high voltage electric cables. He stated that the development of distribution systems in large cities had been hampered by the limited capacity of cables which are used in distributing the power from the generating stations to the load centers.

On February 5, Mr. F. W. Peek, Jr., of the General Electric Company spoke to the Society on the subject of "Lightning." His talk was very similar to the article which he published a short time ago in THE TECH ENGINEERING NEWS.

One feature which has been added to the activities of the Society during the past year is that of encouraging the student members to write and present papers at the meetings. Thus far two such talks have been given. The first by Theodore Taylor, '26, on the subject of Mechanical Analogies of Electric Phenomena. The talk was presented in a very capable manner and was illustrated by a number of very interesting experiments. The second of these talks was given by Ole M. Hovgaard, '26, on the subject of Vacuum Tube Voltmeters. This paper described the general principles of operation of the vacuum tube voltmeter and also some of the experimental work along this line which had been done in the research division of the Electrical Engineering Department. The paper is now being considered in a prize contest for the best "first paper" to be presented before a branch or section of the American Institute of Electrical Engineers.

NAVAL ARCHITECTURE SOCIETY

The Society took two trips this last term, which were very popular. One, to the *Leviathan*, which was docked in South Boston, was especially popular. It should be stated here that the Society has an enrollment of less than forty, but on this afternoon the enrollment in the course was suddenly enlarged to 150 or 200. But the hard-hearted officials of the docking company admitted only those whose names had been sent from the 'Stute as officially enrolled in the course. So the remaining "architects" were put off the boat and "enjoyed" themselves gazing at the outside of the vessel. The others were shown through the ship, but they could not be taken into the engine room because of a company ruling.

A week or more later the Society got permission to visit the Argentine battleship, *Moreno*, which is being reconditioned at the Fore River shipyard of the United States Government. This trip was not so popular with the "architects" who took in the trip to the *Leviathan*, due to the distance of the ship from Boston. Those who went down to the Fore River yards were shown over the ship by the officers in charge and shown many small courtesies, which they did not receive from the officers of the *Leviathan*.

AERONAUTICAL ENGINEERING SOCIETY

The Aeronautical Engineering Society of the Massachusetts Institute of Technology has continued its activity of previous years unabated. It started last fall by enrolling over 150 members and instituting a series of smokers to which prominent men in the field of aeronautics were invited as speakers. Among other guests of the society have been Lt. Noel Davis, in charge of the Squantum Naval Reserve Aviation Training Station; Warren Noble, research engineer, who is at present engaged in the development of airplane motors under Naval specifications, and Lt. Brown, commandant of the Boston Airport and chairman of the preliminary committee on the ground organization of the world flight. A few weeks ago Lt. Leigh Wade was secured to describe the flight as it was actually flown.

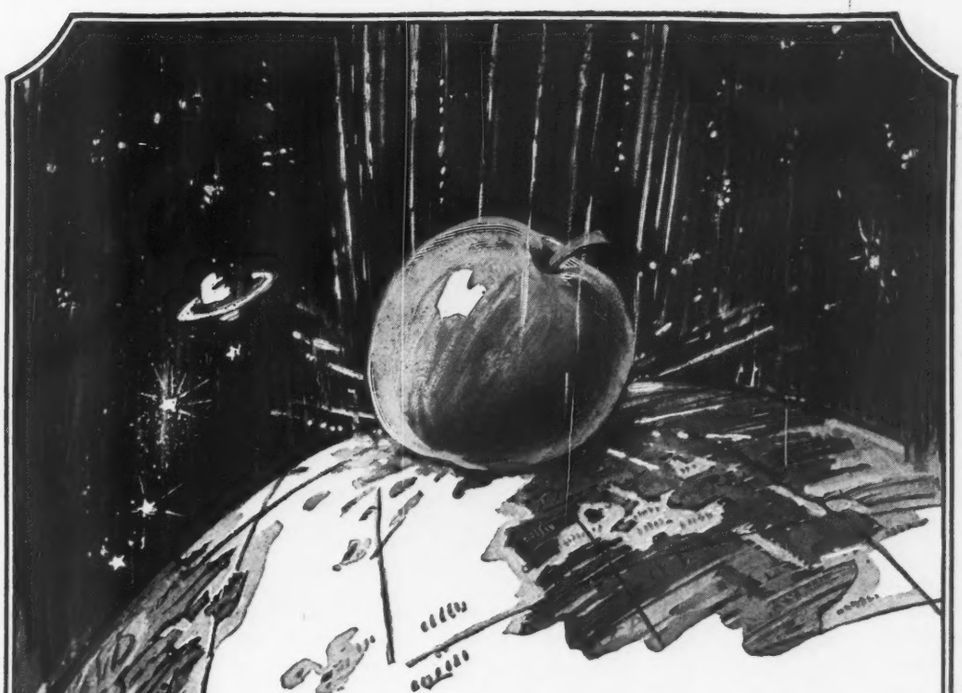
The society is also busy developing plans for the construction of a light plane. A design competition has been held and several promising designs were turned in. A Henderson motorcycle motor has been offered for the plane, but efforts are also being made to secure a Bristol Cherub or some other light plane motor of equal reliability. If such a motor is used the machine will be a two place one. There is no lack of enthusiasm on the part of the members, and the designs submitted are excellent, but it may be impossible to complete the plans owing to lack of funds. During the past few weeks several methods have been discussed for obtaining the required funds, but as yet none have been successful, and the construction may yet have to be abandoned. Such a procedure would be regrettable because of the pioneering work of this organization in the European gliding competitions two years ago. The society is fortunate in having for its honorary vice-president Professor E. P. Warner, head of the Aeronautical Engineering Department of the Institute, who has given many valuable suggestions and assistance.

A number of the members who are enrolled in the Air Service R. O. T. C. are making frequent flights from the Boston Airport. Other members who have taken the preliminary flying course at Squantum are putting in extra solo time on Saturday afternoons, and a large class is taking ground school in preparation for the coming summer's training.

MECHANICAL ENGINEERING SOCIETY

The first smoker of the year was held in the latter part of October. The speaker was Mr. Charles R. Gow, president of the Associated Industries of Massachusetts. He spoke on commercial applications of compressed air and stressed in particular its application to construction work, such as tunnelling and foundation installations. He explained the use and function of the air-lock. But he stressed more the human side of the question, describing the effects of compressed air on the men working in the caissons, stress-

(*Continued on page 300*)



The apple that rocked the earth

"I wonder why?"

In Isaac Newton's mind that question clamored for an answer. Many men had seen apples fall, but this man with the question mark mind found out why they fall—and his answer has helped us to understand the workings of a universe.

Would that we all could get a bite of that apple if it would inspire us too with the "I wonder why" attitude!

Intellectual curiosity is a great and moving force. It mobilizes reluctant facts. It is the stern drill-master which whips into shape that most invincible of armies—sure knowledge.

Curiosity, with the will to sweat out the answer, is the greatest asset you can acquire in your college course. This attribute is needed by industry today more than ever before.

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Power at Niagara

(*Continued from page 282*)

house below the cliff. In the opening of each penstock is a "butterfly" valve, which is a steel disc 23 ft. 6 in. in diameter, operated by oil pressure supplied by accumulators. This valve is to be used when necessary to unwater the penstocks. In the event of repairs to the butterfly valve or its chamber, however, slots in the concrete in front of the valve chamber are provided for the placing of steel bulkheads. Each butterfly valve assembly weighs 170 tons. The 21-ft. penstocks are concrete lined tunnels sloping at an angle of 45 degrees down through the face of the cliff. From forebay to turbine they are each 600 feet long, the lower horizontal section being about 300 feet. A 96-ft. section of the lower end is also lined with 1 3/8 in. riveted steel plate to serve as an anchorage for a penstock valve.

This steel plate lining was formed in rings and skidded back as each new ring was added. A "bull riveter," weighing 20 tons, and operated by compressed air, was slung from a crane overhead to rivet the rings. Rivets 1 3/8 in. diameter and about five inches long were heated to a cherry red. The riveter was so nicely balanced that one man could swing it into any desired position by the use of air-operated worms. Air admitted to a cylinder compressed the jaws of the machine and squeezed up the rivet under a pressure of 150 tons and made a tight joint. A crew of seven men set about 450 rivets a day with this machine, while the same crew working by hand would have driven only about 150 rivets with some withdrawals on account of looseness or overheating. This is the only bull riveter ever developed to rivet a pipe in a horizontal position.

To this lining is anchored the Johnson penstock valve, the chamber for which is enlarged in such a way that the space between valve and outer wall provides a gradually decreasing cross-section area to accelerate the water as it approaches the wheel case. The upstream end of the valve is attached to the penstock lining; the downstream end may travel with the stream and seat against the conical face of the lower end of the chamber. It is a balanced, needle-type valve, having a movable plunger sliding in an internal cylinder. The plunger is of differential form, providing two operating chambers which are alternately exhausted to the air to move the plunger, the hydraulic pressure in the penstock furnishing the sole actuating force. Local or remote control may be used, but the valve is designed to close automatically in case of serious over-discharge. The valve assembly weighs 250 tons.

Foundations for the power house and units are set on solid rock at the base of the cliff. The excavation extends about 34 feet below mean water level in the gorge. Reinforced concrete piers support a huge slab, which acts as a base for the entire unit. The slab of concrete is about 60 feet square, 12½ feet thick, and contains 105 tons of 1½ in. steel reinforcing bars. To the slab is hung the concrete "bell" of the draft tube, and resting upon it are the parts of the machine, other concrete parts, and the water weight. Altogether this slab supports a total weight of 9,000 tons.

The wheel case, containing 32 carloads of castings, is about 47 feet over-all diameter. Inside there are ten fixed vanes to guide the water toward the center. Between the volute and the turbine runner are twenty wicket gates linked together so that they may operate in unison by a connection with the automatic governor. The turbine runner is a single casting weighing 52 tons and is about 15 feet diameter with a shaft 34 inches diameter. It is of the Francis reaction type. Water enters horizontally from the outer circumference, passes between the buckets in the runner, and turning downward over the inner periphery passes down through the draft tube. A concrete cone in the draft tube extends clear up to the turbine runner. While the turbine runner is set seven feet above the mean level of the lower river on account of the possibilities of high water, the draft tube is designed to regain a high percentage of the velocity head of the wheel discharge. The mean effective head is 213.5 feet. The capacity of the turbine is 70,000 h.p.—the most powerful yet built.

Different parts of the project were timed so that construction work would "dovetail" properly. The tunnel was finished just two years after breaking ground, but six months before the first unit was to be ready. This gave an opportunity to drain the canal and clean it without interruption at the plant by the simple expedient of placing cofferdams at the canal ends and using the tunnel for water conveyance. Gates in the new forebay are arranged so that tunnel water may be fed into the older forebays. During the war the canal had been deepened by six feet while under operation. The bottom left somewhat uneven by this process was smoothed up and three bridges were replaced by reinforced concrete structures. Down below the cliff in the new power house, while the Johnson valve, water wheel case, and concrete parts were under construction, the stator and rotor of the generator were assembled at a little distance from the unit. When the concrete floor-slabs over the turbine were set and the base ring for the generator was in place, the stator completed by that time, weighing 228 tons and over 30 feet diameter, was lifted by cranes and lowered into position. While the coils of the stator were being tested and finishing touches applied, the generator rotor assembly was completed. Twenty-eight poles were bolted to the spider, the finished diameter being over 24 feet. When this was ready two 200-ton cranes tied together lifted the rotor weighing 399 tons, and placed it within the stator where its shaft was attached to the shaft of the turbine runner. The generator is rated at 65,000 kv-a., 12,000-volt, 3-phase, 25-cycle, a.c.

Just above the turbine runner is a lignum vitae guide bearing and above the generator rotor is a babbitt guide bearing. The thrust bearing which supports the rotating elements of the whole unit is located at the top. It is a Kingsbury bearing running in a bath of oil cooled by water coils. The weight of the revolving parts, together with the water thrust, is over 500 tons and the speed is 107 r.p.m.

Between the thrust bearing and the generator rotor, and on the rotor shaft is an auxiliary generator of 650 kv-a., 2,200 volts, a.c. This supplies current for the motors which operate d.c. generators for excitation, oil pumps for the governor fluid, and fans for air circulation; in fact, all auxiliary uses, without breaking into the main generator circuits. In the process of starting up the unit, however, this auxiliary generator draws its field current from the power house exciter bus. The automatic governor is located on the top deck above the generator. It is actuated by a fly-ball mechanism and operates the wicket gates between the wheel case and the turbine runner. It is very sensitive and is designed to keep the speed of the generator rotor at 107 r.p.m. under varying loads.

The complete 70,000 h.p. unit weighs 1,750 tons and measures from the bottom of the draft tube to the

(*Continued on page 300*)

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Georgia Vitrified Brick & Clay Co., Augusta, Ga.
Globe Brick Company, East Liverpool, Ohio
Hisylvania Coal Co., Columbus, Ohio
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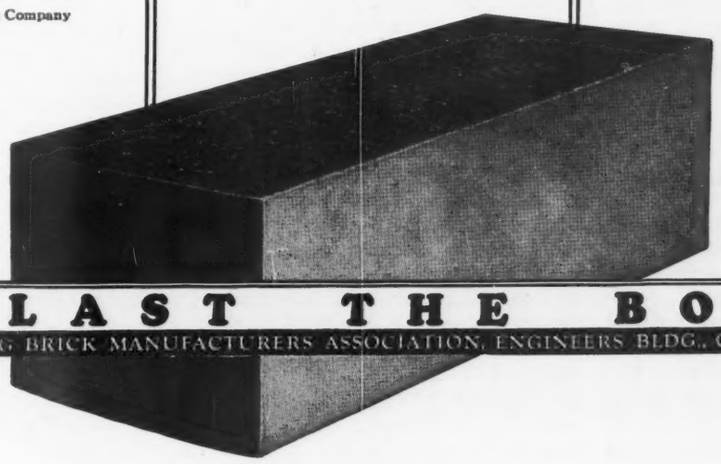


OUTLAST THE BONDS

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION, ENGINEERS BLDG., CLEVELAND, OHIO

Power at Niagara

(*Continued from page 298*)

top of the generator over 86 feet. Some idea of the magnitude of this largest turbine ever built may be had from the statement that its output is enough to supply the needs of a city of 250,000 population. To produce an equivalent output of electricity by the use of coal at the average rate of consumption of coal (10 tons per horse-power-year) would require 700,000 tons annually. It is estimated that one average man can do less than one-tenth horsepower of muscular work. Since man works continuously only eight hours a day, three men are necessary to do that small amount of work throughout the year. Sundays, holidays, and human ills further discount the man-power. It is probably then a safe estimate that in the continuous output of one 70,000 h.p. unit the labor of about three million men is represented. Evidence of the tremendous strides in hydro-electric development at Niagara Falls is apparent in the improved efficiency of these recent units. The same volume of water used in the older plant upstream, which is now held in reserve, produces double the horsepower when conducted through the new tunnel and passed through three 70,000 h.p. turbines. Twenty-one 5,000 h.p. turbines in the older plant have a nominal capacity of 105,000 h.p.; three new 70,000 h.p. turbines, 210,000 h.p. One of these new giants produces as much as 14 of the smaller units and requires only about half as much water. Over 90 per cent of the potential energy of the water used is now converted into electrical energy at the switchboard. Less than 30 per cent of the volume of the Niagara River is being diverted for power purposes on both sides of the river. This diversion is in accordance with the existing international treaty between the United States and Canada. No one connected with the power developments at Niagara Falls, nor with the United States government, which controls all operations there, proposes to use all the water for industrial purposes. The government, however, cognizant of the erosion at the Horseshoe, which cuts the cliff upstream at an average of six feet a year, suggests construction of remedial works in the rapids above the cataract. The erosion occurring at or near the center of the Horseshoe causes an ever-deepening channel near the middle of the river, draws the greater mass of water to that point, and thereby aggravates the condition. The beautiful curve of the cataract, considered by many as one of its most attractive features, is constantly being distorted and a narrow gorge is working up the middle of the river bed, while less and less water finds its way to the heels of the fall. The result is a dense volume at the center, which is more or less obscured by the spray, and a number of bare spots in the crest near the shores. Remedial works could distribute the volume of water so that it would more evenly cover the entire crest and the erosion at the center would be retarded. With such a plan in effect the scenery would be maintained at a high standard and the cataract preserved. Government engineers say that then a very much greater portion of the river's volume could be used without detracting from the scenic effect. They estimate that about fifty per cent of the volume could be diverted around the falls for power purposes. In modern power houses designed for high efficiency, this would provide a source of electrical energy double the present facilities of both Canada and New York State. It would mean the development of three million horsepower and no loss of scenery.

Professional Notes

(*Continued from page 296*)

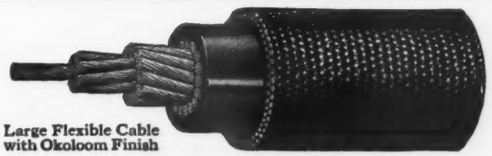
ing the point that it was just as safe to work in compressed air as in the open, as long as proper precautions were taken by those in charge. He also regaled those present with some of his own experiences.

Nearly a month later the second smoker was held. The scheduled speaker for this was Mr. K. C. Moller, '17, but since he was unable to come, he sent a Mr. Hersey to proxy for him. The subject of the talk was "The Engineer" and his relation to the other men in the plant, rather than his relation to the strictly technical side of his job.

On January 20, the first smoker of the new term was held. This meeting was held in conjunction with the Boston Division of the American Welding Society. The speaker was Professor A. S. Kinsey, Advisory Engineer to the Air Reduction and Sales Corporation and Professor of Shop Practice at Stevens Institute. His subject was "Industrializing the Air." He stressed more the application of compressed oxygen to welding processes and gave a demonstration of aluminum welding.

At about this time a large group of seniors and others interested in Automotive Engineering got together and decided that they would like to organize a branch of the Society of Automotive Engineers, so the Mechanical Engineering Society undertook the organization of the Society for them and meetings are held frequently, at which discussions of current automotive problems are discussed. On February 20, Mr. Warren Noble of the Kinney Manufacturing Company spoke to the Society on "Turbulence and Distribution." This covered the subject of distribution of vaporized gas in the cylinder head of the engine.

As an experiment this term, the Society decided to show industrial movies once a week during the term. The first one or two of them were not particularly well attended, but as the term progressed the attendance rose, which would seem to indicate that they are popular with the members. The pictures are non-technical in nature, dwelling rather on the descriptive side of the production. The subjects covered by the pictures are, for example: the manufacture of fibre rope; the manufacture of Portland cement; production of Continental Motors; the fabrication of Wire Rope; the story of brass from the mine to the finished product; Compressed Air and Compressed Air Machinery, and other similar topics.



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POWDER MAKERS SINCE 1802

Reinforced Concrete Design

(*Continued from page 287*)

Stirrups must be so anchored that the allowable stress can be developed at a point 30% their depth from the upper or lower surface of the beam. This is a complication of design that the average designer will not gladly accept, but it does not affect ordinary computations since a stirrup with hooks and well tied to the longitudinal steel is anchored satisfactorily.

The maximum spacing, s, of stirrups and bent-up bars, measured along the axis of the beam, when the shearing stresses are less than 6% f'_c is:

$$s = \frac{45d}{\alpha + 10} \qquad (4)$$

where, d is the distance from the compression side of the beam to the tension steel

α is the angle of the stirrup or bar with the longitudinal steel

Fig. 4 shows the comparison of this equation with the 1916 and 1921 requirements. When the shearing stresses are greater than 6% f'_c the

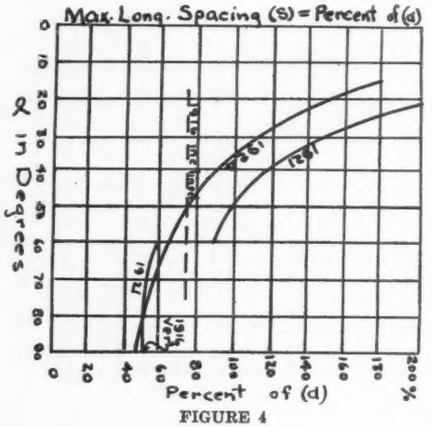


FIGURE 4

spacing shall not be greater than two-thirds the above values.

As explained above, it is customary to figure resistance to diagonal tension in terms of shear. The 1924 report figures the toal shear intensity, v, for rods inclined between 45° and 90° as:

$$v = 0.03f'_c + \frac{f_v A_v}{bs \sin \alpha} \qquad (5)$$

and for inclinations less than 45° as:

$$v = 0.03f'_c + \frac{f_v A_v}{b\ s} (\sin \alpha + \cos \alpha) \qquad (6)$$

where f_v is the unit tensile stress in web reinforcement

A_v is the area of web reinforcement in tension in distance s

b is the width of the beam (Figs. 1 and 2)

s is the spacing of the bars measured in a longitudinal direction

α is the angle of inclination with the longitudinal steel

The term, $0.03f'_c$, becomes $0.02f'_c$, if the longitudinal bars are not well anchored.

At any section the maximum shear intensity, v, can be figured. The portion assigned to the concrete, $0.03f'_c$ is known. The remainder must be cared for by the web reinforcement. Equations (5) and (6) enable one to tie up the shear intensity assigned the web reinforcement with its tensile stress, area, spacing, and inclination. The effect of varying the inclination of the steel can be studied, if a given size of beam and bar is adopted, by solving the last term of equations (5) and (6) for values of α. Fig. (6) gives the values of $\frac{1}{\sin \alpha}$ and $(\sin \alpha + \cos \alpha)$, as α varies from 15° to 90°. The maximum value is given when the bars are bent at 45°, but inclinations as small as 15° do not materially decrease the shear stress carried. Values for angles greater than 45° do decrease rapidly. This is reasonable, as tension cracks can spread more extensively for the same spacing, s, if the rod has a large inclination.

Bond and Anchorage. The determination of the bond stress is made to check the rate of transfer of forces from the steel to the concrete. When the longitudinal bars are on the tension side of the beam, the rate of transfer is governed by the variation of the bending moment. After the bar passes the point of inflection, the rate of transfer depends upon the length of the anchorage. Good anchorage is given by a sufficient length or by some device such as a hooked end.

Critical sections for checking bond stresses are said to be at the point of inflection for positive steel, and at the face of the support and at the point of inflection for the negative steel. Bent-up longitudinal bars at the critical section within a distance of $\frac{d}{3}$ of the horizontal bars can be included in the "sum of the perimeters."

Allowable bond stresses of 4% f'_c for plain bars, and 5% f'_c for deformed bars are in accordance with recent practice. It is provided, however, that higher stresses may be used for designs in which exceptionally good anchorage has been given. This means, for beams, that one-third of the negative steel must be anchored beyond the points of inflection, and one-third of the positive steel beyond the face of the support. At these points these bars shall develop one-third of the tensile stress. Under these conditions the total tension in the bar shall not exceed:

$$F = Q\ u\ \Sigma o\ y + u \Sigma o\ x \qquad (7)$$

where, F is the total tension in the bar

Σo is the perimeter of the bar

Q is the ratio of the average to the maximum bond stress in the distance y

u is the permissible bond stress

x is the length of the anchorage, including the hook, if any

y is the distance from the point at which the tension is computed to the point of beginning of anchorage

Judicious design may give F rela-

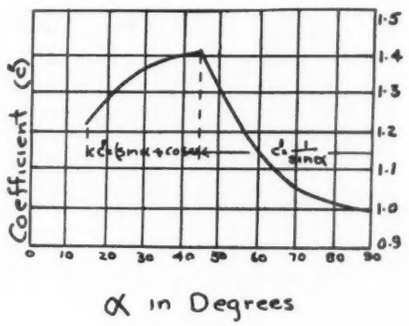


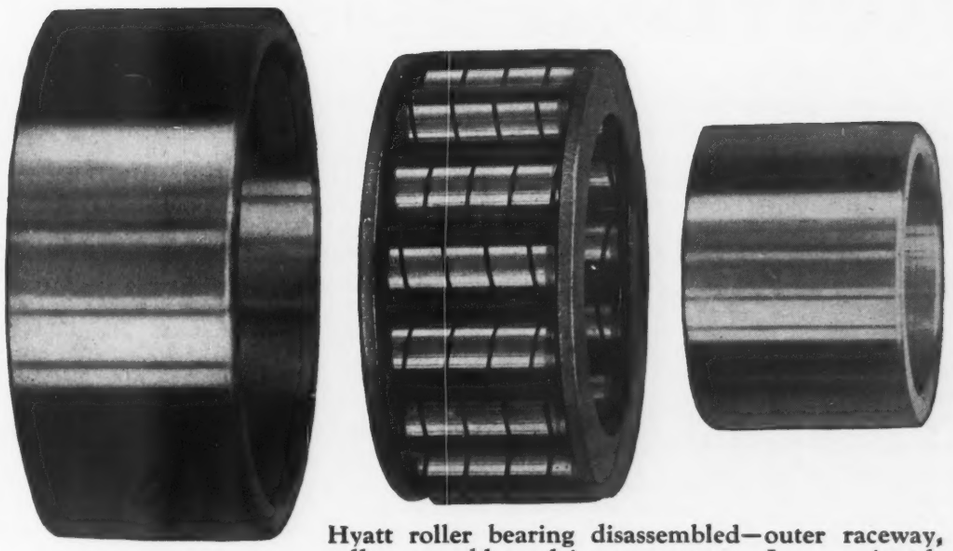
FIGURE 5

tively high values. This formula ought to be very attractive to the hard-pressed designer of reinforcement limited by bond stress.

The changes recommended for diagonal tension and bond give greater precision to the methods of procedure. There is not, however, any simplification of method and only the urge of a saving of materials will induce the ordinary designer to use these added complexities.

Flat Slabs. The design of flat slabs is still based on the analysis by Mr. John R. Nichols. His derivation gave a coefficient for the sum of the positive and negative bending moments of 1/8 (0.125). Comparison with load tests of floors led the 1916 report to adopt a coefficient of 0.107 (86% of 1/8). Further investigation led the 1921 and 1924 reports to call this coefficient 0.09 (72% of 1/8) and to divide, for two-way and four-way reinforcement, the total moment into

(*Continued on page 304*)



Hyatt roller bearing disassembled—outer raceway, roller assembly and inner raceway. In some installations the inner raceway is eliminated, the rollers operating directly upon the shaft.

Anti-Friction Bearings For Modern Mechanical Equipment

THERE was a time when men—even engineers—were satisfied with plain friction bearings for wheels and for other revolving parts of mechanical equipment.

But the day of the plain bearing has passed with that of high collars, pointed shoes and other friction producing devices.

Modern industrial methods require, and enlightened engineers demand that rotating parts be mounted on bearings that will roll instead of rub. The results of using anti-friction bearings are obvious—less fuel and power consumed, less lubrication required and infinitely less bearing wear.

Not only automobiles, but rolling stock, machinery and equipment of all kinds now operate on anti-friction bearings.

Hyatt roller bearings have been pioneers in this field. For over thirty years they have been eliminating friction and showing the way to better and more economical operation of equipment in virtually every line of human endeavor.

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HYATT ROLLER BEARINGS

Reinforced Concrete Design

(*Continued from page 302*)

positive and negative moments in the column and middle strips. Both these reports include a terrifying formula for the minimum thickness of the slab or dropped panel, and formidable formulas for the compressive stress in the concrete. In fact, there is little change from the 1921 paragraphs, but a much more definite procedure than outlined in 1916.

Columns. The 1916 committee made their recommendations for short columns only, those whose unsupported length was less than 15 diameters. Short columns are now called those whose unsupported length, h, is less than 40 times the least radius of gyration, R. The load, P', carried by long columns is less than the load, P, figured for short columns by the equation:

$$\frac{P'}{P} = 1.33 - \frac{h}{120\,R} \qquad (9)$$

The design of columns reinforced with longitudinal bars and ties has been changed by allowing one to use the full cross-section in computations instead of the area within the ties. Based on the full area, the per cent of steel has been reduced to limits between one-half and two per cent; the actual amount of steel has been reduced to a less extent. The allowable compressive stress is also reduced to 20% f'_c. The new recommendations enable the smaller columns to carry somewhat greater loads but the maximum load of the larger columns is less than in 1916.

When the column also contains spiral steel, the same design formula is used but higher stresses are allowed. Only the concrete area bounded by the spirals is counted, but one to six per cent of longitudinal steel can be used, with at least one-quarter that volume as spirals. The allowable compressive stress varies with the per cent of longitudinal steel from values about 30% to 45% f'_c.

Composite columns, in which a steel or cast iron column is embedded in the concrete, were treated with reserve by the 1916 committee and the design indicated in general terms. The present committee, with accumulated test data, gives allowable stresses for the concrete of 25% f'_c and straight line formulas for the steel or cast iron stresses.

Footings. This section has been added since 1916. It agrees in methods with the standard text books. One specific addition is the procedure to determine the stress on top of a pedestal or footing, directly under the column. The dimensions of pedestals without reinforcement are specified.

Retaining Walls. This section has also been added since 1916. It summarizes what has been regarded as good practice for recent years.

In conclusion one can say that these successive reports gain steadily in definite statement, but, perhaps necessarily, increase in complexity of design. Combinations of concrete and steel in monolithic form are not easy to handle with a logical theory. As increased knowledge leads to possible economies of design, the approximations, simple in form, tend to disappear; but the concrete structures, themselves, will continue to stand, we believe, enduring for ages, adequate for their load, and beautiful to behold.

Recent Automobile Shows

(*Continued from page 281*)

in one case the manufacturer is not averse to replacing the vehicle every year or two by the sale of a new vehicle, while in the other case the operator expects to obtain the maximum life and mileage before the vehicle is discarded.

The development of motor trucks in the past year has been largely a matter of refinement in detail. The four-cylinder engine continues to be the power plant generally used, owing to low maintenance and operating costs. The electric truck is becoming more popular. While the first cost of an electric truck is greater than that of a truck having an internal combustion engine for a power plant, the saving in operating costs is considerable. For congested traffic work the electric truck is proving more able than the horse-drawn vehicle.

It has become the custom in the larger cities to have a Salon where custom bodies and the more expensive cars are on display. These luxurious and comfortable creations are always of interest, for what is the custom body of today may be the production body of tomorrow. Perhaps the one feature of the custom closed body is the elimination of blind spots that interfere with the driver's vision.

Accessories that were only little used a few years ago are now considered necessities and many manufacturers sell their cars completely equipped. Bumpers, rear view mirrors, windshield wipers, stop lights, backing lights, heaters, clocks, cigar lighters, etc., are now looked upon as a part of a well-equipped car.

Competition in the automobile business has always been keen. Now, in addition to the competition in selling cars, there is competition in service. As the unit service operation costs are being standardized and used by most manufacturers, it means that the design of motor vehicles must be such that service can be rendered quickly, easily and cheaply. This will bring about simple design, will make more service operations possible by non-skilled labor, and will result in lower maintenance costs.

A peculiar situation has been created by the automobile. In all the publications dealing with motor cars in this country, not a word of criticism is to be found. Take for instance the voluminous Sunday newspapers. Many pages are filled with glowing accounts of the wonderful performance of various vehicles. Turn to the theatrical news and there the critics do not hesitate to discuss the shortcomings of productions or actors. It means that every man must be his own critic at an automobile show. Many a nickeled radiator has shielded an engine of mediocre performance.

To sum up the current automobile shows it may be said that never before have such values been offered. As there have been no startling improvements in the past year, the cars now have been tried and proved. The reduced prices are due to improved manufacturing methods and the fact that if a model is improved a factory is not forced to spend the vast sums needed to tool up for a new model.

An engineer can visualize the physical, chemical, metallurgical and mechanical skill needed to produce and produce in quantities the successful automobiles of today. If there is any question as to the value of these machines, remember that on the pound basis a good automobile costs about one half what a pound of good candy does.

HOW "CATALOGUE STUDIES" CAN HELP YOU

We wish to call the technical student's attention to Volume 14 of "Catalogue Studies"—available in your college library or engineering department—in which are bound some of the Hercules Powder Company's contributions to the technology of blasting.

This contains the following publications: Eliminating Waste in Blasting, Hercules Explosives and Blasting Supplies, Scientific Quarry Blasting, Shot-firing by Electricity, Flotation: a Brief Survey, Land Development with Hercules Dynamite, Land Clearing and Wood Utilization by Distillation, Hercules Galvanometers and Rheostats, Increasing Lump Coal Production by Cushioned Blasting, Hercules Flotation Oils, Hercoblasting, Dynamite: the New Aladdin's Lamp.

Each of these booklets provides clearly-presented, practical information on how to use explosives effectively and economically. These publications have been of great help to many men in the field and are carefully preserved by them for ready reference. By becoming acquainted with this material, you will acquire information that may be of great value to you in your profession and which many engineers do not get until faced with the actual need. Should you wish separate copies of any of the booklets listed above, write to the Hercules Powder Company, 941 King Street, Wilmington, Delaware.

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WILMINGTON, DEL.

The Powell - Leverage Motor

(*Continued from page 290*)

mal flame travel, dissipates heat rapidly and has a small bearing surface.

A Powell Leverage Motor has a small diameter piston due to the fact that the total displacement of an engine is a function of the cylinder diameter and the length of piston stroke. If one is large the other is small, or, both may be equal, in which case we would have a so-called square-engine.

Now in order to obtain in a Powell Leverage Motor a certain displacement, the stroke being 8 inches, the cylinder diameter will usually be smaller than one-half of the piston stroke.

Among the advantages resultant from the utilization of a piston having a small diameter might be mentioned:

a. Light weight piston.
b. High compression.
c. Short distance of flame travel.
d. Rapid dissipation of heat.
e. High thermal efficiency.
f. Small bearing surface on cylinder walls.

(*a*) A light weight piston would reduce the total reciprocating mass thereby reducing the inertia which would result in a smoother running engine and would also reduce the size of the bearings.

(*b, d, e*) These items are so correlated as to make them dependent upon each other. A high compression is necessary to increase the thermal efficiency and can be obtained if the rate of heat dissipation of the piston is rapid.

(*c*) A short distance of flame travel through the mixture is obtained by using a small diameter piston in that a more compact combustion chamber can be employed.

(*f*) As the diameter of the piston employed is small, its length is correspondingly small, and the area producing friction by sliding on the cylinder wall is therefore low.

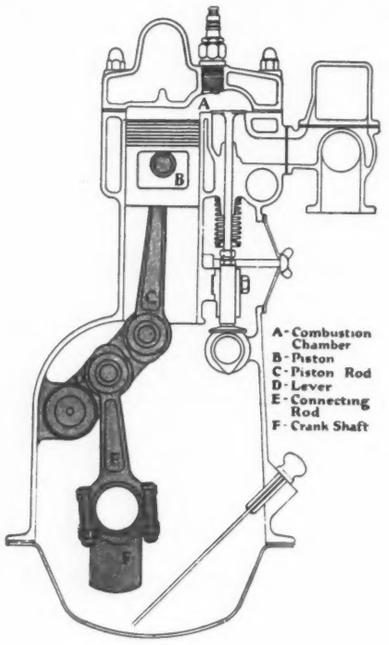
Reduction of the piston rod angularity in a Powell Leverage Motor reduces side thrust and lessens friction loss.

Fuel economy of an engine is dependent to a great extent upon the mechanical friction and as the piston friction is the greatest source of mechanical friction in an engine, it follows that to reduce it would increase the thermal efficiency. The piston rod's angularity is the greatest contributing factor causing piston friction, so that in reducing it a gain can be expected.

The angularity of the piston rod in a Powell Leverage Motor is reduced to about one-half of the angularity found in an orthodox engine.

Small crank shaft throw of Powell Leverage Motor reduces vibration and wear on main bearings.

As the crank shaft stroke in a Powell Leverage Motor usually equals 4 inches, it is readily understood that the following advantages are easily attained:



POWELL LEVERAGE MOTOR
The piston is not connected directly to the crank shaft but has a compound lever between the piston and the crank shaft.

a. Low centrifugal force.
b. Little wear and tear on main bearings.
c. Small crank shaft.
d. Light weight crank shaft.
e. Minimum torsional vibration.
f. Few main bearings required.

The above points should not need any further explanation, as a little thought will answer any question which might be raised.

Slow r.p.m. of crank shaft allows low gear ratio in transmission provided the required torque is delivered.

By increasing the load factor on an engine, through a reduction of the rear axle gear ratio, the number of miles per gallon is increased. It is a well known fact that the nearer an engine works to its maximum delivered output, the greater the thermal efficiency and hence the more useful work it will do.

Piston rods and connecting rods in a Powell Leverage Motor are placed slightly off center so that there is no possibility of the rods of a Powell Engine ever being on absolute dead center on the effective portion of the explosive stroke.

By referring to a plotted motion drawing of a Powell Leverage Motor, it will be seen that when the rods are at the limit of their upward movement the lower connecting rod is inclined at an angle of 1½ degrees to a vertical line. The lever is inclined at an angle of 45 degees to said line. The piston rod is inclined at an angle of about 2½ degrees to a vertical line. This would decrease the tendency to back fire.

Through the use of a lever having a 2-to-1 ratio in the Powell Leverage Motor the total pressure on the piston is doubled at the connecting rod, neglecting rod angularity.

The lever is similar to a reduction gear in that it reduces a high piston speed into a slow r.p.m. of crank shaft.

From the accompanying diagramatic sketch, it will be seen that the Powell Leverage Motor has a conventional combustion chamber, "A," into which combustible gases are admitted, exploded and expelled.

The cycle used is the familiar Otto cycle or more commonly called the 4-stroke cycle, as used in practically every automobile engine.

The piston "B" reciprocates in the cylinder exactly as in every engine, differing only in the length of travel thereof.

The piston rod "C" is connected to the piston "B" and also to the outer or free end of the lever "D." The crank case wall serves as the fulcrum of the lever. The upper end of the connecting rod "E" is operatively connected to the midpoint of the lever "D" which gives a leverage of 2 to 1, that is (neglecting rod angularity), a one-pound pressure on the piston will be multiplied by the leverage so that the pressure is two pounds at the connecting rod.

The lower end of the connecting rod "E" is secured to the crank shaft "F" in the usually accepted manner of a split bearing and standard S. A. E. connecting rod bolts.

(*Continued on page 308*)

GRANITE FOR PAVING AND CURBING

The main constituents of granite are quartz and feldspar. Both are harder than steel and are very nearly indestructible.

Hardness is an important property of all granites and is defined as the resistance of a mineral to abrasion or scratching. It is usually explained by comparing with Moh's scale which is ten minerals arranged in the order of increasing hardness as follows:

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2 Gypsum	7 *Quartz*
3 Calcite	8 Topaz
4 Fluorite	9 Corundum
5 Apatite	10 Diamond

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Powell-Leverage Motor

(*Continued from page 306*)

Due to the use of a lever giving a ratio of 2 to 1, the diameter of crank pin travel will be approximately one-half of the distance travelled by the piston in one stroke.

Now let us assume that the piston is at the limit of its upstroke and the spark has just passed. Due to the increased pressure of the expanding gases the piston will descend, forcing down the piston rod, which in turn forces the lever to move downwardly describing an arc of a circle about the fulcrum, the radius of which is equal to the length of the lever. As the lever moves downwardly on its fulcrum, the connecting rod will descend which in turn transmits motion to the crank shaft causing it to rotate about its center.

While the cross sectional view of the Powell Leverage Motor shows a four-cylinder engine, any conventional number of cylinders may be employed.

Mississippi River Delta

(*Continued from page 289*)

of a plan for the improvement of Southwest Pass. This project contemplated a channel thirty-five feet deep and 1,000 feet wide. Jetties were constructed in 1905, but the discharge is about three times that of South Pass and the problem of maintenance is correspondingly large. The sediment deposits have caused the bar at the mouth to advance as rapidly as the jetties have extended seaward. Gulf currents are unfavorable, and unstable foundations have been met with where it was necessary to place great weight. The desired channel dimensions have never been approached and it seems that under the existing plan they will not be.

The discharge through South Pass has been metered to record as much as 250,000 cubic feet per second in high water. This water will run approximately one one-thousandth sediment by volume, which means that at times 250 cubic feet of sediment per second is being deposited by this pass alone. In the face of this it seems remarkable that a navigable depth of over twenty-six feet has been maintained for over forty years. This success is due principally to the jetties constructed by Eads, yet it cannot be entirely so due, for similar jetties have failed at Southwest Pass. It is likely that excess shoaling at the mouth of South Pass has been avoided, not alone by the jetties, but by the particular location of the jetties with respect to the gulf eddy currents across their mouth. At least the different effect of similar jetty construction would seem to indicate such a possibility.

At the time of the writer's leaving Port Eads an extensive investigation of the eddy currents, salinity, sediment, etc., of the waters at the mouths of the two passes was being started and it is not unlikely that in the past few years a solution of this unusual engineering problem has been indicated.

Most Powerful Electric Locomotive in World. There is now under construction at the Highland Park plant of the Ford Motor Co., an electric locomotive, larger and more powerful than any yet built. The engine is for freight service on the Detroit and Ironton Railway. It will weigh 340 tons and will be 117 feet long, 15 feet high and 10 feet wide. Its running speed will be 17 miles per hour and its maximum speed 35 miles per hour.

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The photograph above shows a section of pipe being lowered into the ditch in the process of laying it.

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The Evolution of the Ship

(*Continued from page 288*)

thing drastic if he wished to carry on. Freedom of trade had, however, helped as well as harmed him, as it left it open for him to purchase foreign ships, which he promptly did, and some of the finest of Donald McKay's Boston-built clippers were purchased. This made the British shipbuilder wake up, also, and led to a keen international struggle. One disadvantage that the British shipbuilder had was a lack of suitable timber for building the larger sized vessels, so that, generally, his ships were smaller than American clippers until he adopted iron frames in place of wood. This composite construction as it was called, by abolishing the need for curved timbers, at once put him on the level with his New England competitor, and the transverse strength of such ships being much greater than that of the "all wood" vessel, soon suggested the advisability of replacing the whole of the wood with the newer material. This was a mutation similar to those of nature, but relatively greater than the mutation which led to man himself, and in the course of about ten years, the iron ship had made it almost impossible for her wooden sister to compete. Not only was the first cost less, but the hull was lighter, and so she could carry a heavier cargo. Her repair bills were smaller, and her useful life at least double that of the wooden ship, and consequently she carried reduced depreciation charges. Probably, however, her great advantage was in the better condition in which she delivered her cargoes. The wooden ship was never thoroughly water-tight and there were, consequently, heavy claims for damaged cargo. The iron ship, on the other hand, rarely leaked and, provided the hatches were properly battened down, could be counted on to land her cargo in excellent condition. The difference in insurance on this account alone, would have been quite sufficient to enable the iron ship to dominate; added to the other advantages, it made her victory overwhelming.

A Boston ship owner of the old school, who owned twenty-five of the finest clippers of the wood era, told to the writer a few days ago that the iron ship had made it quite impossible for him to carry on. The step from iron to mild steel was a comparatively small one. The new material was much more expensive at first, but the saving in weight, due to its greater strength, made it worth while, even in the beginning, while the improved methods of manufacture soon brought the cost of steel below that of iron. Since then the progress has been more in a nature of slow, steady improvement of the hull, due to more scientific structral design. The mutations have been confined largely to the propelling power. An attempt, however, was made to introduce reinforced concrete as a shipbuilding material; doubtless suggested by its success in bridge and other land construction. The problem of ship design, however, is entirely different from that of a bridge. In the latter, stresses are mostly static and of constant nature, that is, tension members are always tension members, and compression members are always in compression. When a ship is tumbled about in the seaway, she has six degrees of freedom and

(*Continued on page 312*)

for Insulation

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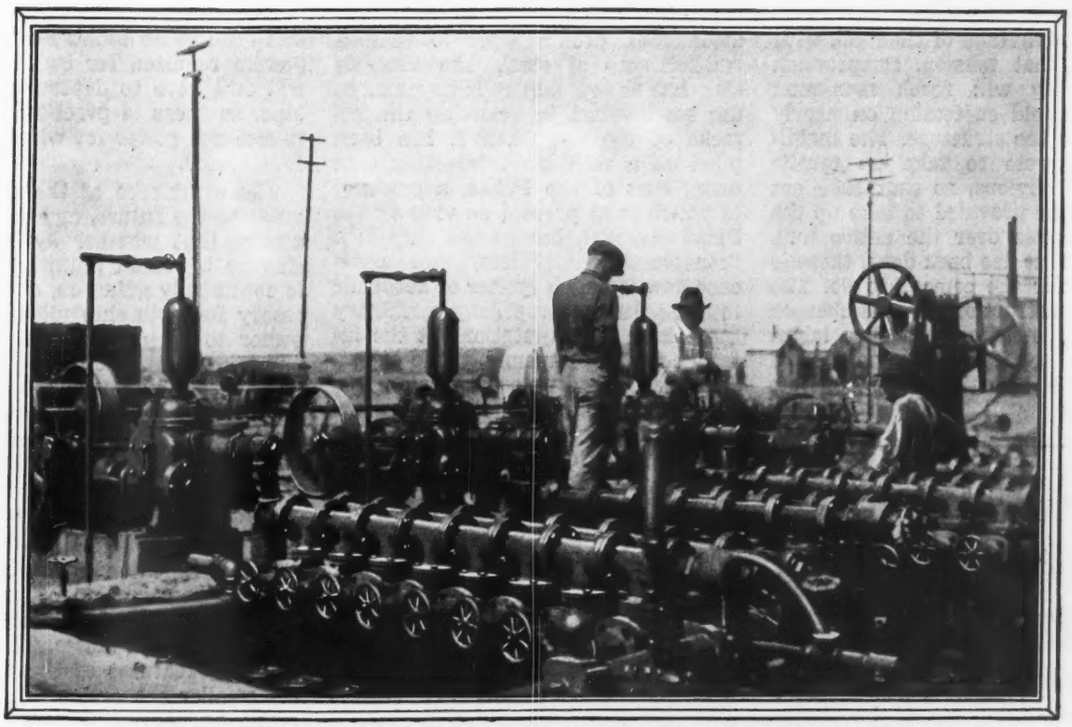

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Wash Sink of Enameled Iron, No. Y-391

The Evolution of the Ship

(*Continued from page 310*)

takes full advantage of them all, with the result that tension, compression and shearing will reach maximum values in rapid succession on nearly all parts of the structure. The inability of concrete to take up tensile stresses is obvious, so that sufficient steel must be provided to take up the tensile stresses over the entire hull, and when that has been done, there is little left for the cement to do. The concrete construction can use cheaper sections of steel and cheaper labor, but it is necessarily heavier, and therefore, in any given ship, concrete construction will carry a smaller amount of profitable cargo than a smaller ship of steel. The concrete ship has shown that it is superior to the steel vessel in resisting the attacks of the sea when it has been piled on a rock, an interesting case being that of the *Pelias*, a painting of which is at present on view in the Pratt Museum, but as the ship is a "constructive total loss," her existence now is only a matter of academic interest. In the propelling machinery there have been mutations at the introduction of compound, triple expansion and quadruple expansion engines, and again with the steam turbine and the geared turbine. Each of these innovations brought its own troubles, and for a time it looked as if each would have to be dropped, but the troubles were quickly overcome. The case, however, appears to be different with the application of superheat. Here the theoretical gain is very marked, and most of the new passenger ships built immediately after the war were fitted with up-to-date superheaters, but the owners have been finding that the economy only exists on paper, and that they have been paying about 120 cents for every dollar's worth of saving in fuel, with the result that not only are superheaters being omitted from new ships, but they are being taken out of existing ones whenever their repair bill becomes large. The most recent mutation has been towards the internal combustion engine and here, again, the troubles have been numerous, but are being slowly overcome. Their enormous fuel economy is especially important on long voyages where much fuel has to be carried. As each ton of fuel saved means a ton more of paying dead weight, there is much to be said in favor of the Diesel engine. Of the various types—two-stroke, four-stroke, single-acting and double-acting—it is yet too soon to say which will be the survivor, but that one of these forms will eventually dominate in moderate sized engines, there can be no doubt. For the higher powers required for swift liners, we will still have to depend on the turbine, as there is practically no limit in size and power for which it can be constructed.

The experience of the past is our guide to the future, and it clearly indicates that whether by slow evolution or by rapid mutation, progress is continually going on, and it is necessary for both shipbuilder and shipowner to keep abreast of the times and take advantage of every improvement, great or small, if he wishes to hold his own in what is one of the most keenly competitive modern activities.

Vibration Process of Concrete Highway Construction—The use of machine vibration to consolidate concrete in construction of roads is becoming increasingly noticeable in the Middle Western states. The two outstanding features of the process are the smaller proportion of cement and small aggregate to total aggregate used and the use of machine methods of consolidation. The former characteristic is made possible by the latter, the vibration and pressure consequent on the use of the machine forcing the coarser particles closer together and therefore requiring a smaller proportion of cement and small aggregate to fill the intervening spaces. Construction methods are the same employed in ordinary concrete work except that broken stone is forced into the green concrete surface by machine vibrators. The latter consists of a gas-driven machine mounted on small trucks. These are propelled by hand over wooden mats. The advantages claimed for the process are: (1) Economy of machine consolidation; (2) Exceptionally strong and dense concrete; and (3) less care in protecting the finished surface and quicker use of the road. —*Engineering News Record.*

Capitalize Your Technical Training

Changing conditions in the commercial world have created new openings for engineers.

It was the engineer who solved the problems incident to mass production and made possible low manufacturing costs. But those in charge of distribution did not keep pace with the progress of the engineer.

And now business is turning to the engineer for help in reducing distribution costs. Technically trained men have splendid opportunities in the field of business.

Business Leadership

These new conditions open the way for engineers to a new business leadership. But to make the most of your opportunities you should supplement your technical training by acquiring a knowledge of the fundamental principles of business and their application to daily business problems.

To help you minimize the time, usually spent in gaining such experience, the intensive, one-year training course of the Babson Institute is offered.

From actual experience the fundamental principles of business are made clear. By positive examples, the student is shown how to apply these principles in the conduct of every day commercial affairs.

Write for Booklet

Send for booklet "Training for Business Leadership." This booklet describes the courses in detail and gives complete information about the facilities of Babson Institute and shows how men are trained for executive roles. Write today. No obligation.

Babson Institute

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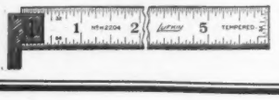

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THE LUFKIN RULE CO. SAGINAW, MICHIGAN
NEW YORK WINDSOR, CAN.

With Cap and Pipe

LEAN and tanned from work in the open, pipe in mouth, cap pulled well down—that's the erecting engineer, as pictured in the magazines, and generally as found on the job. In an organization like Westinghouse he occupies a pivotal place, being responsible for the erection of equipment in the field.

Take him in the electrification of the Chilean State Railway, for example—one of the outstanding electrical projects of recent years. It included not merely the electrification of 134 miles of steam lines, but also power and substation equipment to convert water power from the Andes Mountains into electric current.

In 1922 the first shipment of substation equipment departed—but ahead of it had already departed a force of Westinghouse erection engineers. They went to a country that was a stranger to railroad electrical operation, and to the installation of large electrical equipment. In the 134 miles of steam railway to be electrified they encountered every kind of topographical and engineering condition—curves, grades as steep as 2¼ per cent and as long as 12 miles, bridges extending to 440 feet, six tunnels, the longest 1,600 feet.

Today, two years later, these same erection engineers are returning—returning from a Chile, much of whose railway traffic is moved by its water falls; they are returning and promptly *departing* again on still other missions of electrical improvement, at home and abroad.

This advertisement is sixth in a vocational series, outlining the fields for engineering achievement in the Westinghouse organization. A copy of the entire series will be sent to anyone requesting it.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

WESTINGHOUSE ELECTRIC

Helium

(*Continued from page 285*)

may become exhausted, or the two may coincide most unfortunately.

Our helium resources consist of certain natural gases occurring in several western states, all of which have been discovered incidental to drilling for oil or gas. Their helium content varies from a few hundredths of one per cent up to about two per cent by volume. Under present conditions 0.5 per cent of helium is considered the lowest limit, the extraction of which would be commercially feasible, but with future improvements of process, we may expect to go considerably below this limit; such has been the history of all processes of mineral recovery. We have large quantities of helium in gases above 0.5 per cent, or even above one per cent, but unfortunately it is being wasted at an alarming rate.

It is estimated that the present loss by failure to recover is several hundred million cubic feet of helium a year, or enough to fill a whole fleet of Zeppelins. These wastes of helium could be stopped in two ways: (1) By legislation. The only proposal in this direction has been for the United States Government to acquire helium reserves for military use. One such reserve was set aside on public land in Utah in March, 1924. No other discovery of helium has been made on public lands and hence additional reserves would have to be purchased or leased. Legislation is now before Congress providing for a conservation fund, which, if enacted, would enable the purchase or lease of enough reserves for the Army and Navy use for a long period of years. Our present knowledge of helium resources indicates that after such reserves have been set aside there would be left a large and sufficient quantity of helium for commercial use.

(2) The second method of conserving helium is for the owner himself to hold it for its future value, or for a commercial company to establish its own reserves. There is nothing to prevent such action now, but the use of helium has not yet reached a stage regarded as warranting it.

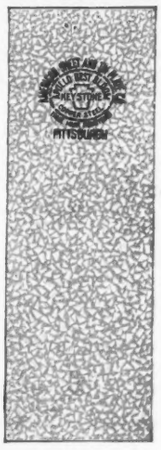
(*Continued on page 316*)

Black and Galvanized

SHEETS

TIN AND TERNE PLATES

We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—American Bessemer, and American Open Hearth Steel Sheets, Keystone Copper Steel *rust-resisting* Sheets, Apollo Galvanized Sheets, Formed Roofing and Siding Products, Culvert and Flume Stock. Sheets for Special Purposes, Roofing Tin Plates. Bright Tin Plate, Black Plate, Etc.



AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.

Every engineer should have our booklets describing Keystone Copper Steel

The Tech Engineering News

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is published monthly, October to May, and contains Articles of general Scientific and Engineering Interest besides many of Institute Activities.

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VAC-M Arresters Will Protect Fire Alarm Apparatus

against lightning and other electrical disturbances.

Here's what a chief who has them in service has to say:

"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

The National Electric Specialty Co.

Toledo, Ohio

BRINGING MORE DAYLIGHT INTO INDUSTRIAL BUILDINGS.

Dr. George M. Price, writing on "The Importance of Light in Factories," in "The Modern Factory," states: "Light is an essential working condition in all industrial establishments, and is also of paramount influence in the preservation of the health of the workers. There is no condition within industrial establishments to which so little attention is given as proper lighting and illumination. Especially is this the case in many of the factories in the United States. A prominent investigator, who had extensive opportunities to make observations of industrial establishments in Europe as well as in America, states: "I have seen so many mills and other works miserably lighted, that bad light is the most conspicuous and general defect of American factory premises."

"My own investigations for the New York State Factory Commission support this view. In these investigations it was found that 36.7% of the laundries inspected, 49.2% of the candy factories, 48.4% of the printing places, 50% of the chemical establishments, were inadequately lighted. There was hardly a trade investigated without finding a large number of inadequately lighted establishments."

Inadequate and defective lighting of industrial buildings is not confined to the establishments in New York State alone. The same conditions prevail in most sections of the country.

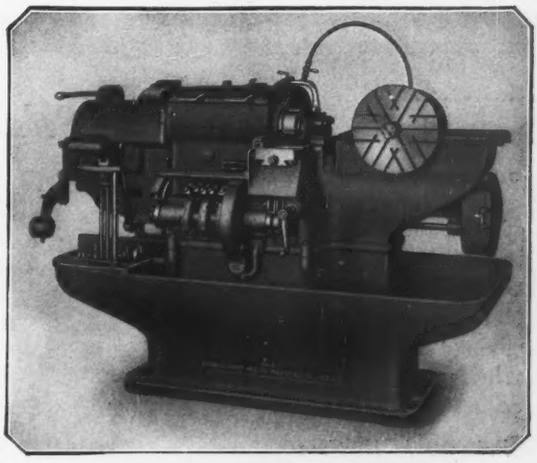
Such conditions as mentioned above are entirely opposed to the laws of health, sanitation and efficiency. Wherever poor lighting conditions prevail, there must be a corresponding loss of efficiency and output both in quality and in quantity. American industry is not using nearly enough daylight and sunlight in its buildings. Every endeavor should be made to use as much as possible of daylight for lighting purposes. To obtain this it is of course necessary that the rays of daylight and sunlight are permitted to enter the interior of the buildings as freely as possible, with the important modification that the direct rays of the sun must be properly diffused to prevent glare and eyestrain. A glass especially made for this purpose is known as Factrolite, and is recommended for the windows of industrial plants. Windows should be kept clean if the maximum amount of daylight is to pass through the glass, but the effort will be well repaid by the benefits secured.

In the presence of poor lighting, we cannot expect men to work with the same enthusiasm as when a well lighted working place has been provided. The physical surroundings have a deep effect upon the sentiments of the employes, and where bad working conditions are allowed to prevail, there is invariably a lessening of morale and satisfaction created thereby. Neglecting to utilize what nature has so bounteously provided, daylight, and which is so essential toward industrial efficiency, we have an instance of wastefulness, but now that the importance of good lighting is becoming recognized, undoubtedly more attention will be given by progressive industrial employers to furnishing the means which are essential for their workers to secure and maintain the efficiency, which counts for so much in the success of any industrial concern in this competitive age.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

Why interchangeable parts can be made at low cost—



BROWN & SHARPE Automatic Screw Machines
are one of the big reasons

THE low cost of parts for automobiles, sewing machines, typewriters, etc., is due entirely to quantity production. Many of these parts are made from bar stock and Brown & Sharpe Automatic Screw Machines are often responsible for the fast rate of production secured.

These machines when once set-up and supplied with stock, work automatically and perform each operation with a high degree of accuracy.

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U.S.A.

Helium

(*Continued from page 314*)

The situation is unique in some of its aspects. The discovery of a helium-bearing gas well is too rare to justify prospecting for helium alone. The discovery must come incidental to the search for gas or oil, but in this way the helium is subjected to waste or total loss. Some time it will be regarded as a valuable by-product, but possibly not until depletion shall have progressed too far. Today we have a world monopoly. If we waste this priceless resource before or during its development some other country with the future monopoly may enjoy the benefit of our development and demonstration work, to our great industrial and military disadvantage. When the conservation of helium for military use has been provided for the field data which are now held confidential can then be opened up for the benefit of the owners of helium-bearing gas, as well as for the prospective commercial purchaser or user.

So far the only other discovery of helium of any importance is that in Canada of a rather limited quantity of natural gas bearing 0.3 per cent of helium. Several thousand cubic feet of helium were extracted from this gas in an experimental plant by Professor J. C. McLennan and Mr. J. Patterson. It is more than striking that Canada with these hitherto limited resources, already possesses the necessary legislation for the future conservation and utilization of helium; while this country, so richly endowed with natural resources of helium, has as yet taken no steps for their proper conservation or protection.

One of the latest developments in the use of helium is the erection by the Bureau of Mines of a repurification plant for the Navy at Lakehurst, New Jersey. The plant was designed to repurify helium from the gas bags which had become contaminated with air by diffusion. It has a capacity of about 480,000 cubic feet of gas per day and can therefore repurify all of the gas from the Shenandoah or Los Angeles in a matter of five days. The purity attained is about 98 per cent. The loss of helium in the operation is not more than one per cent and the cost is less than $1.00 per thousand cubic feet of helium, or a small fraction of its original cost of production. A high state of purity is very important from the standpoint of its lifting power, since the loss of each per cent of purity by the introduction of air entails a loss of lifting power of about 4 per cent. It will now be both simple and economical to keep the gas at high average purity by frequent retreatment, which would not be possible in the case of hydrogen, as already pointed out, owing to the explosibility of the mixtures that would result upon compression in the refrigeration process.

BUFF Instruments

save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

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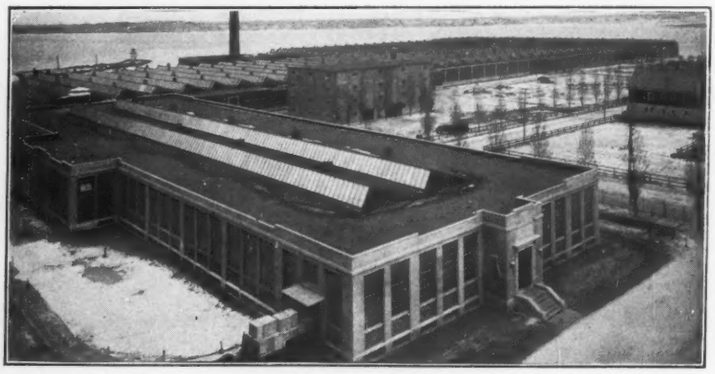

One of the finest textile mills in world built by Wm. T. Reed Co. Several repeat orders have been received from this firm

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We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions

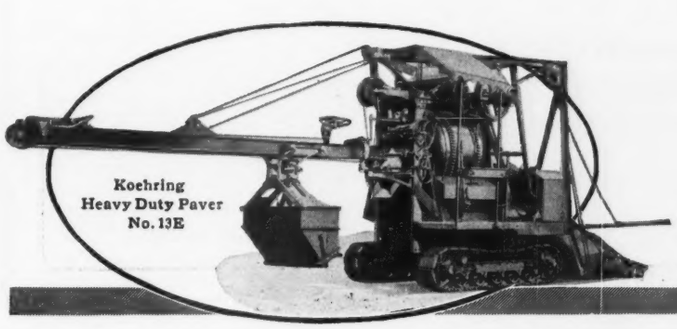
Stamina and Dependability

A concrete mixer receives about as hard usage as any machinery designed—and a great deal harder than most.

The record of the Koehring Paver shown above may, therefore, appear unusual. This mixer, purchased in 1913, has been in continuous use for 12 years and today is ready to begin another full season's work. The total repair bill to date is $300.00.

Koehring Pavers and Mixers are the accepted equipment wherever concrete roads are built and construction work carried on.

"Koehring Heavy Duty" is a phrase the significance of which is understood and appreciated wherever construction equipment is used. It is synonymous with equipment of the highest grade of manufacture, built to deliver maximum operating service over a period of years.


Koehring
Heavy Duty Paver
No. 13E

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MILWAUKEE WISCONSIN
Manufacturers of
PAVERS, MIXERS—GASOLINE CRANES
DRAGLINES, SHOVELS

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first-year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

PUBLICATIONS

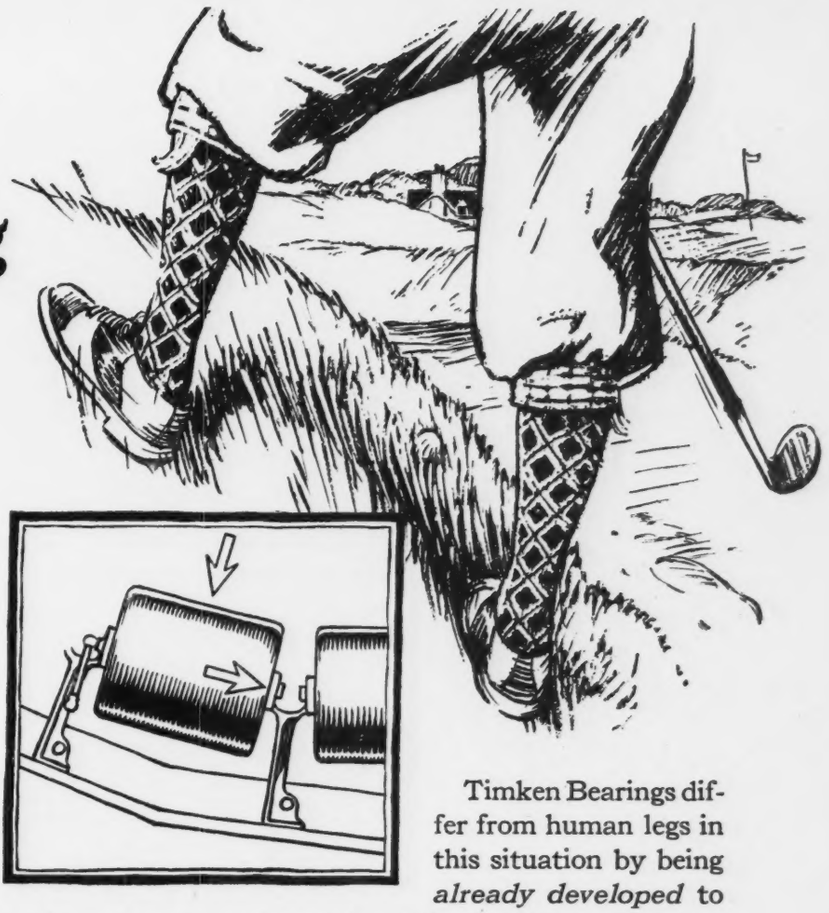
Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.

Which Leg Gets the Weight?



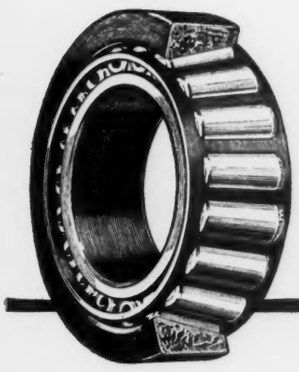
In time, Nature would answer this question. Make a habit of standing in this posture, and your right hip would become larger, due to the added muscular development.

There are conditions in industry when wheels and pulleys must operate under conditions similar to those of the body in this position. One example is found in the pulleys of a troughing conveyer—particularly those pulleys which run at an angle. In addition to the straight up and down load resting on the bearings, there is a definite *thrust* load that also must be carried.

Timken Bearings differ from human legs in this situation by being *already developed* to carry continuously such loads. They are designed for intermittent thrust loads and for permanent thrust loads. The Timken tapered principle is the explanation.

From whatever angle the load comes—whether straight up and down, or from a side—it is evenly distributed over the entire length of the rollers. Hence the long wear. Hence, too, the wide use of Timken Bearings in every field of industry.

The Timken Roller Bearing Company
CANTON, OHIO



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Tapered
ROLLER BEARINGS

Stage directions for this scene from William Vaughn Moody's play, "The Great Divide," call for a woman's muffled scream, a pistol shot, and the crash of breaking furniture. The microphone on the right sends them all to your home.

An Exciting Evening

Here are four of the WGY Players (the world's first radio dramatic company) at a thrilling climax that almost turns sound into sight.

Tune in, some evening, on one of their productions. You will be surprised to find how readily your imagination will supply stage and setting.

WGY, at Schenectady, KOA, at Denver, and KGO, at Oakland, are the broadcasting stations of the General Electric Company. Each, at times, is a concert hall, a lecture room, a news bureau, or a place of worship.

If you are interested to learn more about what electricity is doing, write for Reprint No. AR 391 containing a complete set of these advertisements.

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